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ABSTRACT

The investigation of ultrafiche technology and its applications in higher education resulted in an unanticipated far-reaching study on the general use of microforms. This occurred when it was found (1) that reader presentations of typical educational materials were of excellent quality throughout the range of reduction ratios investigated, 32x to 150x, and (2) that student reading rate and comprehension when using reader presentations of materials were independent of reduction ratio and essentially equal to that obtained on hardcopy. These developments transformed the study from one exploring "Can a student use an ultrafiche presentation?" to one that asked "Will a student use a microform presentation?" "Broad usage on a routine basis" was accepted as the overall application criterion. The study of microform application was approached in two ways. One approach considered library application from the economic and administrative standpoints; the other centered on applications that could have great value to many students, i.e., those consistent with routine usage. In addition to the development of these applications, experiments were undertaken to explore the utility of microform presentation in terms of user performance and user acceptance. An attempt was made to identify the presentation factors operative at the interface of man and machine which create negative attitudes toward the use of microforms, and to organize these factors into a conceptual framework to show both relationships and fundamental considerations for improving acceptance. Two secondary research projects were also conducted during the course of the investigation. In one study, the library at the University of Denver was characterized from the separate viewpoints of the microfiche systems designer and of the microfilming specialist through an analysis of a sample of books. The second study developed a method for evaluating image quality in terms of readability and of visibility. A discussion section in the report integrates the separate studies into a consistent statement on the considerations involved in microform publishing (particularly ultrafiche) for educational applications. Objectives in continuing the overall program are also discussed. (JH)

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Memo to: Recipients of the report, *An Investigation of the Characteristics of Ultrafiche and Its Application to Colleges and Universities*, August 31, 1969.

From: James P. Kottenstette
Denver Research Institute
University of Denver

Subject: *Errata*

My apologies for not detecting the errors prior to the report mailing.

page A-32 paragraph 1: $200 – $2.208 = 962 titles in fiche
should read: $200 – $0.208 = 962 titles in fiche

page A-48 paragraph 2, last sentence: Table XV
should read: Table XIV

page E-9 under Legend: Pressure Group
sould read: Pleasure Group

page E-11 Table E-2: 120x
should read: 150x

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A program of this type is unusual because its success largely depends on participation by manufacturers that have more than a passing interest in its outcome. Three manufacturers participated in this study: The National Cash Register Company of Dayton, Ohio; Microform Data Systems, Inc., of Palo Alto, California; and Eastman Kodak, Inc., of Rochester, New York. We can only understate our appreciation for the cooperation obtained and the professionalism exhibited by these organizations throughout this program.

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AN INVESTIGATION OF THE CHARACTERISTICS OF ULTRAFICHE AND ITS APPLICATION TO COLLEGES AND UNIVERSITIES

PROGRAM SUMMARY AND MAJOR CONCLUSIONS

The investigation of ultrafiche technology and its applications in higher education has resulted in a far-ranging study which comments on microform use, in general, in addition to ultrafiche as a specific topic. This unanticipated scope resulted when it became obvious that reader presentations of typical educational materials were of excellent quality throughout the range of reduction ratios investigated (32x to 150x). While a quality differential was detectable as magnification increased, it was found that the presented image, at 150 times magnification, still compared favorably in readability with the original hardcopy that was filmed. While this result was unexpected, it is clearly the product of an optimized application of microimage technology while initial expectations were based on sub-optimal technology.

A carefully designed reading experiment determined that students could preserve skill levels (reading rate and comprehension) when utilizing reader presentations of material ranging from the descriptive to the subtle and abstract. In this comparison of performance on readers against that obtained on hardcopy, the role of reduction ratio was examined; thereafter it was dismissed since performance was independent of reduction ratio as well as being essentially equal to that obtained on hardcopy. Instead of a focus on technical differences attributable to high reduction, the emphasis was directed toward differences in presentation aspects and user reaction to these differences. This development transformed the study from one exploring "Can a student use an ultrafiche presentation?" to a study that asked "Will a student use a microform presentation?" The implication is clear: if reduction ratio is not self-limiting in the range investigated, nothing distinguishes an ultrafiche presentation from any other microform presentation as far as the user is concerned.

The question of "Will a student use microform?" was probed on the assumption that use would be routine rather than exceptional. A model was developed and given preliminary testing in which the man-machine interaction was viewed as an interface containing discrepancies that were of two major types: either reinforcing or neutral. Reinforcing discrepancies are encountered with each frame of presented information and cause negative attitudes to form on the part of a user by forcing the user to formalize his own model of expectations concerning the interface. Neutral or non-reinforcing discrepancies can be tolerated because they appear to be "part of the system" and do not provoke the user to frame his expectations concerning them. Paralleling the importance of identifying types of discrepancies, another series of user experiments indicated that the information communicated must be substantive and make demands on the user in order to minimize the user's concern with the reader and detailed aspects of its performance.

An experiment comprised of "search" tasks which were difficult and frustrating shows that the user quickly evaluates the reader process in terms of a substitution for a book or hardcopy. Once the alternative is recognized, the user makes comparisons and becomes aware of discrepancies and begins to formalize his expectations.

Discrepancies in the user-reader interaction have been classified as to presentation equivalence, task accommodation, and environmental adaptation. In terms of presentation, reinforcing discrepancies include "hot spot," scintillation, dirt, and nonuniformity of focus; task accommodation discrepancies include frame-to-frame focus and frame positioning; adaptation discrepancies include machine placement positioning (and size).

Conclusions and Recommendations Based on Experimentation

1. User acceptance of microform presentations hinges on overcoming reinforcing discrepancies in the man-machine interface.

2. Discrepancies can be recognized and appropriate design steps taken to minimize effects if the proposed application is analyzed by identifying differences between the microform system and the "old" or "existing" system that is to be replaced.

3. The use of small screen size is attractive for presentation of book materials since approximately 90% of these materials have less than a 9-inch height and a 6-inch width (information area). This statistic favors small reader design.

4. Information should be organized on a fiche by column rather than by row. This recommendation has major user advantages, and is one of the principal recommendations to publishers in ultrafiche. This change in format makes precise framing possible (side to side) and

vertical framing arbitrary: framing difficulty is the principal disadvantage of a small screen size and this change in format effectively overcomes framing difficulty. This format change does no violence to existing fiche or readers, but has particular application for ultrafiche since a large number of frames are available in a column. The columns, themselves, could be used as a basic tool for organization of the information contained on the fiche.

5. The characterization of image quality using the random grain pattern technique has clarified the respective concepts of readability and visibility as operative in high-reduction, high-density microimagery. For the application considered, i.e., education, it is the readability that must be preserved; current technology can maintain high readability at high reduction ratios.

Conclusions and Recommendations Based on Applications Studies

1. Routine use of microform depends primarily on the creation of a valuable information base responsive to a wide range of student information needs.

2. Ultrafiche should be the microform used to create the information base. Economic feasibility has been demonstrated only for the creation of a "core" library having large numbers of titles in the collection; such a collection would be very attractive on a cost basis to small or new educational institutions but would become less attractive to larger institutions (libraries) as the amount of duplication is increased. The success of a library collection representing all types of material appears to be pivotal before single ultrafiche publications will be available. The economic feasibility of other educational uses ~~for~~ ultrafiche have not been considered in this report.

3. Special collections on ultrafiche are already being planned. The basic attraction in these ventures lies in the low cost per title acquired; but the nature of the material at this time (historical) promotes exceptional rather than routine use of the microform.

4. Unfortunately, a "best" reduction ratio cannot be identified for the sake of uniformity between competing publishing ventures. It remains the responsibility of the marketplace to judge the system that best responds to the particular needs of education. Reduction ratio is only one system parameter and it is not critical to a responsive system design.

INTRODUCTION

The investigation of ultrafiche and its educational applications is an unusual research program -- as will be obvious in the remainder of this Interim Report. On 1 July 1968, the project staff was concerned with the technology of ultrafiche; its applications were seen as limited by the state of the technology in terms of the demands that would be made on it by the diversity of educational and library materials, and by a student's ability to effectively utilize educational materials made available in the high image density that characterized ultrafiche.

Now, in August 1969, the project staff is concerned with ultrafiche only in the sense that it is an extension of the inclusiveness of the microform family: a best microform for a class of materials that requires hundreds of frames in order to preserve the integrity of the filmed document (book-length materials, specifically). The concern about effective use of materials filmed at high density has broadened to be a concern about the effective use of microform presentations from the viewpoint of the user and from the vantage of the enabling system.

Applications are not limited by the technical considerations in making a high quality fiche (an important requirement for any reduction ratio); they are limited by the requirement that an application must have true value to the student -- not just an administrative value. It should be emphasized that applications, as discussed in this report, imply "broad usage on a routine basis." There should be no confusion on this point. Microforms are widely distributed in the educational environment at this time, but the present user group is a limited one rather than a broad group, and use is exceptional rather than routine. Applications can be characterized by this distinction: it must be appreciated that the distinction leads to an enlarged problem scope when routine use is accepted as an application criterion. In education applications, the only motivation for utilizing a microform presentation arises from the information needs of the student as perceived by the student and not by the administration. An application anticipating exceptional use is not required to respond to the range of systems considerations involved in an application based on routine use because the exception is synonymous with great need and high motivation which can overcome system defects. Routine use implies variable motivation which will not overcome system defects.

We have considered applications in two ways in this report: one presents the library application from an economic standpoint and discusses the feasibility of ultrafiche publication in an administrative context. It assumes that the reservoir of microimagery is of general utility and could be used routinely; the arguments developed concern costs as they are differentiated by publishing philosophy and by constraints in the specifics of the microform itself, and these costs are compared with the hardcopy alternative. The second approach to application includes current publishing ventures using ultrafiche but is extended to consider applications that can have great value to many students; applications that are consistent with the routine use of microforms because of this value.

In addition to the applications that are developed, this report presents some rather detailed experimentation that comments on the barriers created when a machine-fiche combination is inserted in the normal channel of educational communication. This exploration of the man-machine interface considers the utility of the microform presentation in terms of user performance and user acceptance. Performance is considered from the viewpoint of maintenance of cognitive skill levels with the insertion of the interface, and its dependency on characteristics peculiar to the interface. Acceptance is explored from a behavioral standpoint. An attempt is made to identify the presentation factors operative at the interface which create negative attitudes towards the use of microforms, and to organize them into a conceptual framework which shows both relationships and fundamental considerations for improving acceptance.

A description of two secondary research efforts is also included: in one study, the library at the University of Denver is characterized through the analysis of a sample of the book materials. In this analysis, the physical characteristics of the library volumes were developed from the viewpoint of the microform systems designer, and the typographical characteristics were developed from the viewpoint of the microfilming specialist. By creating an information base which contains both types of data from a common sample, the statistics reservoir upon which any micropublishing effort basically depends is appropriately dimensioned. A second study describes a method of evaluating image quality in terms of readability and of visibility. This distinction is quite important in order to understand why the high-density, high-reduction technology is able to create excellent image quality for educational purposes over the range of typographic variations encountered in the input reservoir, thus explaining why this report does not deal with ultrafiche in the context of technically limited applications.

The extensive use of appendices in the format of this report was dictated by the diversity of the research accomplished in the program to date. These appendices are designed to "stand alone" so that only a short summary of each will be presented in the body of the report. The main objective sought in the following discussion section is the integration of the separate studies into a consistent statement on the considerations involved in microform publishing (particularly ultrafiche) for the educational applications. The basis for certain recommendations lies in the experience and research reported in the appendices; therefore, no attempt will be made to justify in great depth the recommendations presented. Justification resides in the work presented in the appendices taken in total this approach makes greater demands on the reader but it is dictated by the strong role that values play in a complex question involving individual perception.

DISCUSSION

This research has touched upon four areas that strongly affect the whole concept of educational microforms. These areas are:

1. Ultrafiche applications (Appendix G) and the economics of the library application specifically (Appendix A).
2. User performance and fatigue characteristics (Appendix B and E, respectively).
3. Factors affecting user acceptance of microforms (Appendix F).
4. A method for measuring typographical characteristics and determining image quality (Appendix C), and the nature of library materials as the information to be filmed (Appendix D).

The breadth of the investigation is obvious from the enumeration; and the reader is invited to refer to the appendices for a complete development of each topic. The descriptive information presented at this time must be limited to an attempt to integrate the material into a useful whole by supplying the required context for consideration of a particular topic and then generalizing from the specific studies described.

ULTRAFICHE APPLICATIONS AND THE ECONOMICS OF THE LIBRARY APPLICATION

As the early experiments of this program were studied, it became quite apparent that ultrafiche technology was simply an extension of the microimagery which has been commonly used up to this time for a limited number of applications characterized by a limited audience. It is unique in that it represents a refinement in photoreduction and in magnification processes which permits a considerable extension in use mode, in applications, and in user base for the microform medium, due to its potentially high frame density; this characteristic permits single works, or multiple related works, totalling up to 3200 images or pages, to be placed on a single film card. Therefore, the feasibility of publishing book materials in this medium now becomes practical from a physical point of view, and its application to the area of education becomes a significant consideration. An ultrafiche, having both vertical and horizontal components of image placement for the organization of information, permits the user of a well-designed card to access most rapidly any one of the great number of pages making up the one or more complete titles it contains merely by moving the fiche slightly. Since it has been recognized that ultrafiche is just one of the forms of microimagery, the choice of a specific microform for a particular application, has been correspondingly widened from previous concepts of useful application. The real question is, "How can we best make use of this increased potential to benefit the educational system in colleges and universities?"

For the most part, existing microforms encountered in the institutional setting have limited use by nature of their content and reflect an administrative solution to acquisition or storage of specialized materials. From the limited body of users of present microforms on a university campus, it is now possible to consider extending the user group to involve the total student body. In considering this possibility, one can view the information needs of this total population as those (1) "structured" and fairly predictable, and as those (2) "unstructured" and fairly spontaneous. The structured information needs stem from the classroom situation where an instructor defines the course material rather specifically. The unstructured information needs develop as the student follows his individual inclination to learn and pursues this quest thru extended materials, particularly those held in libraries. This suggests that information demands on an educational institution can, in a general sense, be divided into those classroom related and those library related.

Several advanced proposals have been designed to create large ultrafiche collections for college libraries. They would enlarge the unstructured information base but, since the contemplated collections would essentially exclude copyrighted materials, their historical character greatly minimizes the potential user base. A "core collection" which would have to include copyrighted works, would involve a much larger proportion of the student body since there is greater demand by more individuals for contemporary materials. This application will be studied in detail a little later.

Another application of microforms that could be used by colleges has to do with computer search and would serve individual needs through greater library capabilities in making information available. This could be facilitated thru a network in which individual college libraries were tied to a regional computer search center which would address relevant abstracts on a particular subject, the abstracts being maintained at all local institutions. The abstracts could then be read for relevance and the location of complete works. The computer-reader combination can, in the near future, make extended information available to the individual scholar. (This application is not limited to ultrafiche of course: it is a microform application).

The third area of application pertains to structured needs, and is the most difficult of the three to describe adequately because it is a departure from the present way that structured information needs are treated. As mentioned earlier, structured information needs are a consequence of present instructional methods. In terms of total demands, the structured needs are the most pervasive at any educational institution. This pervasiveness is confirmed by the presence of the "book store" and the acceptance of a textbook as the usual method for supporting classroom instruction. The ultrafiche technology presents an alternative for meeting these structured needs. Before describing this alternative, it would be well to reflect on why the textbook is presently used, and focus on its main limitation. Basically, the textbook offers a convenient vehicle for instruction: it is organized in a logical manner, and each student is brought to a common reference plane. A particular text(s) is selected by the instructor in response to his individual judgment and prejudice, and at the undergraduate level, particularly, the viewpoint projected is normally the only one encountered. This is not a serious drawback because the instructional level is generally basic, and the student cannot be expected to purchase numerous texts in support of each class. The library itself offers direct compensation for this problem in that other sources are made available. The point that should be evident is that the textbook, its content and form, have evolved in response to factors that subordinate the information content to marketing considerations. If the argument is acceptable, it follows that a modification of the marketing constraints might also modify the interpretations of structural information needs that are classroom derived.

One possibility for new interpretation lies in the concept of "information units." A parallel might be drawn between the concept of information units and the relatively recent publishing innovation by which authors write various sections of a book, with the sections unified by an editor or editorial board. The concept of information units is an extension of this approach. The chief difference is that the scope or range of the materials presented would not be restricted to a certain length as decreed by marketing judgments. In the short run, these information units might simply be the selection of books having a common theme, organized by difficulty or competing viewpoint, but unified by presence on a single film card. As this application becomes mature, the information units would become a bridge between report material and text material with each unit drawing on whatever source and to whatever extent is dictated by the editorial objective. The most important aspect of this concept is that the structured information base would no longer be so limited as in the past and would be far more responsive to the pursuit of knowledge in a given course of study. This concept directly affects information science and has social implications as well.

Two barriers exist to the development of full-scale microform use in the college classroom and library: (1) copyright law, and (2) necessary individual readers (machines). These barriers are artificial; readers (at prices amenable to individual ownership) do not exist because they have not been generally needed; with an expanded requirement the necessary machine technology will respond. As to copyrighted materials, publishers will publish in microform if it is profitable to do so. The most important roadblock to extended use of microforms and the development of "information units" in support of classroom activities, is that no one can yet say if there will be a market. It might well be that the "extension service" or "correspondence school" operations of universitites or institutes will originate or demonstrate a market, as such materials for these courses are often copyrighted by the institutions themselves. This outline of possible ultrafiche applications can be closed on a note of caution: the true application responds to the information needs of the student. It must do more than meet administrative criteria if the student is to utilize microform other than on an exceptional basis.

One of the strongest reasons for undertaking the study of ultrafiche, besides the apparent "fit" between the length of book materials and the number of frames on an ultrafiche, was the very attractive cost picture. It was estimated at the beginning of the program that copies of a high density fiche, containing between 8 and 12 complete titles, could be obtained for about one dollar assuming a large distribution of fiche copies would be required. It was clear, however, that this estimate had little to do with total costs associated with a fiche (assuming that it is part of a mature publishing concept). In order to establish a frame of reference for the consideration of ultrafiche as a publishing form for educational material, the most easily conceived application, that of expanding institutional collections, was explored in detail. As seen above, this is not the only application of interest, but it is an area of commercial activity presently and it can be argued that the library application will be the most significant at least in the short run.

GENERAL ECONOMIC CONSIDERATION[1]

In order to make the economic development meaningful, two problems had to be resolved initially: first, that the nature of the material committed to microform controls the extent of the library market (i.e., the number of volumes, the subject area, and the contemporaneous nature of the material); and second, that the difference in physical characteristics of ultrafiche at 40x versus those at 150x (the range defined as "ultrafiche" for purposes of this study) decrees that the systems for fiche creation and utilization have differing economic bases as well as form.

The first problem dealing with the nature of the material was constrained by associating it with the maturity of an institution's library collection. This process yields significant insights: many small colleges have modest collections (320 institutions with less than 17,000 volumes; 820 with less than 38,000 volumes),[2] a condition which suggests that general works, of broad scope, including current publications which would form a "core" collection, is requisite. On the other hand, a "core" collection would be serious duplication for mature libraries; the material needed is specialized, implying subject diversity and a selection process (institutionally) for relevant titles. These observations led to a choice of two fiche publication schemes which were evaluated; a large collection model in which 20,000 titles[3] on general works was postulated, and a single-fiche model in which materials in ultrafiche would be acquired much as present materials are acquired in current library operations.

The second problem, the significance of reduction ratio in dimensioning both cost and form for utilization was controlled by developing an economic reference for each of four reduction ratios: 40x, 80x, 115x, and 150x, in terms of committing 20,000 titles to fiche.

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[1] This work was done under subcontract to Technomics, Inc., and the general results are presented in Appendix A.

[2] From American Library Association Survey, 1966.

[3] Twenty-thousand titles was arbitrarily chosen, but it recommends itself because it is the number established as a standard for Junior colleges (with enrollment under 1,000) by the ALA.

This approach was taken in order to contrast costs as a function of reduction ratio, and set the stage for consideration of the value elements implicit in the utilization of ultrafiche publications in a campus library.

Manufacturing Costs

The overall fiche size considered in this study is 4 by 6 inches. One-stage reduction filming is envisioned for 40x, while two-stage filming is expected for the other reduction ratios. Information to be filmed was considered to be sized up to 9 by 12 inches, and a fiche design was developed which reserved an area on the left side for machine reading, and an area at the top for "eye" legible print.

At high reduction, economic use of fiche requires they hold more than one title, except in the case of 40x which would accommodate only 231 frames-- consistent with area assumptions. For this study, title units have been blocked off on the face of fiche so that there is one unit per fiche at 40x, two units at 80x, four at 115x, and eight at 150x. From a sample library study at the University of Denver, the number of titles requiring one, two, or more title units have been determined from the number of pages involved in books making up the sample. From these calculations, the number of fiche needed for 20,000 volumes have been determined for each reduction ratio (although not the minimum number obtained by matching short and long books).

Items involved in establishing costs for manufacturing a collection of 20,000 titles in ultrafiche include filming and the fiche masters. These costs must be distributed over the number of sets produced; further, a high and a low estimate of these manufacturing costs have been calculated to cover the range of probable costs. At 40x, these manufacturing expenses for a single set of the material (involving approximately 6,520,000 images) ranges $508,000 to $834,000; this goes down to a cost per set, out of 3000 sets, ranging $7,945 to $8,054. At 150x, such manufacturing costs for a single set of the material range from $729,000 to $1,898,000, and this goes down to a cost per set, out of 3000 sets, ranging $3,281 to $3,671; in this latter case, the larger initial production costs at 150x are sharply reduced when 3000 sets are involved because of the minimal number of fiche per set required to hold the information. Table A-IV of Appendix A lists estimated costs per unit for varying numbers of sets produced at the four reduction ratios; Figure A-3 of this same Appendix graphically shows total costs to the manufacturer for filming and fiche masters for producing the various numbers of sets of 20,000 titles in the four reduction ratios.

The Single-Fiche Model

To provide a basis for considering publishing in fiche form, a single title at a time, costs of producing books need to be reviewed. One might assume a book would have its retail price broken into the following costs and in the following proportions:

manufacturing costs	16%
author's royalty	10%
editorial costs and publisher's profit	24%
dealer's discount	20%
marketing costs	10%
library discount	20%

Ultrafiche could reduce manufacturing costs by perhaps 2/3, but that would only be 2/3 of the 16% involved in manufacturing costs and all the other items would still have to be taken into account in the cost of the single title in microform. But, there is a saving in space for storing the fiche rather than a comparable book in hardcopy, and it can be envisioned that shipping, handling, and warehousing costs would go down for the item, although marketing costs may go up to promote the item in fiche form.

Within the library world, it is difficult to compare costs in broad terms because different libraries are directed to different goals, have different procedures to meet their goals, and face different administrative costs. However, certain basic costs within all libraries bear on the application of ultrafiche as contrasted with books. First, there is the purchase price of the title which would not differ much from book to fiche; selection costs should be the same; circulation costs should not vary much from books to fiche, tasks involved in processing one form would undoubtedly be offset by different tasks involved in processing the other form; but, one can look at storage space for books as against reader space for servicing fiche, as well as miscellaneous costs of book maintenance and retirement, and find some differences in costs to the library function between fiche and books that are significant because housing represents perhaps 30% of the total cost involved in having a title in the library collection. Appendix A shows storage and book maintenance costing about 20.8¢ per book per year. Converting this base figure into annual costs for a reader and reader space results in replacing 962 books per reader (carrel space) in the high reduction fiche, and in replacing 635 books per carrel at 40x microform, but, it has been postulated that about 1540 titles per reader would be an appropriate mix.* (This figure may be high or low depending upon the proportion of microforms to books in the entire collection, and the normal potential number of users of the particular library). The overall cost per reader (per 1540 titles) over a 50-year period, should on this basis lower housing costs 20% for low reduction fiche as opposed to equivalent books, and 12% for high reduction fiche. However, this savings could not accrue unless the large numbers of titles appropriate to the use of each reader involved are indeed present at the library. The purchase of only a few fiche can actually add more in space and reader costs than equivalent books; therefore, single fiche acquisitions are feasible cost-wise only when a sizeable ultrafiche collection already exists at a library.

The Core-Collection Model

The core-collection for this study is assumed to be 20,000 titles produced as a package, covering all fields of knowledge, supporting a college program heavily dependent upon the library. The production of such a collection is a major undertaking and the fixed costs to produce it are great. An estimate must be made of the point where production of such a collection becomes feasible economically for both publisher and consumer, and this is primarily dependent upon the size of the market and the reduction ratio decided upon.

The most significant single problem to be resolved in putting a core collection on the market for colleges and universities has to do with royalties. It has been estimated that about 80% of the titles that should be included in a core-collection at first printing in ultrafiche would be under copyright. Varying royalty arrangements may come about as the problem is rigorously pursued to actually accomplish such a project as is considered here; for the purposes of this effort it is assumed that 80% of such a collection, or 16,000 titles, would be involved in copyrights and that these could be used at $1 per title, thus adding a flat $16,000 to any unit price arrived at for any particular reduction ratio or particular market size for the collection.

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* The difference here between books replaced and the number of fiche serviced per reader represents space (cost) savings.

The costs of publishing a core-collection must consider an array of extensive tasks and the correlation of many functions. Involved are editorial tasks, copyright investigations, bibliographic development, production and manufacturing, and marketing. It has been estimated that two years would be needed from initial planning for a core-collection until the first unit is delivered. Both fixed costs and incremental costs would be involved; the fixed costs would include all that must be done to produce the initial set of fiche masters and develop the market; the incremental costs would cover the manufacturing and distribution costs to deliver the product. The fixed costs would be amortized over the number of sales made; the incremental costs would relate to the number of packages produced. For example, fixed costs per unit package for a market of 3000 units at 80x (the most expensive reduction ratio) is about $1,850 (estimate) and incremental costs about $11,600, totalling around $13,450. At 150x, these items would approximate $1,200 in fixed costs and $3,200 in incremental costs, totalling around $4,400.

In addition to the actual fiche containing the monographs, a library should be provided with a catalog for the collection. The cataloging of a core-collection at the source should provide libraries with the savings associated with this function. It is envisioned that such a bibliography would consist of both a book catalog and a fiche catalog. A card catalog would be provided but would be expensive and should be separately costed. It appears that the collection catalog should contain lists of authors, titles, subjects, and shelf list. Three sets of book catalogs should accompany each set of fiche. Production costs of these book catalogs are both fixed and incremental; the incremental costs can be estimated at $245 per unit in a market of 3000 units. These bibliographic aids (in book form) would cost the same for all reduction ratios.

The per unit (20,000 title package) cost to a library of a core collection would vary considerably both with reduction ratio employed in preparing and presenting the material and in the number of buyers. Table A-XII of Appendix A is a tabulation of cost per unit or set for the four reduction ratios involved here and markets from one consumer up to 3000. These figures must be read with the realization that they do not include royalties or profit to the publisher. The most expensive condition at the present time (but there is reason to believe that this will change shortly) involves the 80x reduction ratio. As an example, assuming a market of 1000, unit cost at 80x is shown to be estimated currently at $17,296 to which must be added royalties and publisher's profits: assuming a market of 3000, this unit cost is lowered to $13,569. At a reduction ratio of 150x (showing the lowest cost tabulated), assuming a market of 1000 results in a unit cost of $6,869 while assuming a market of 3000 for this reduction ratio results in a unit cost of $4,477, again without consideration of royalties and profit. It is necessary that reading machines be provided to service a collection of ultrafiche titles and that space be provided for these readers to be used. Also, with this number of titles, it would be necessary to have reader-printers available. In considering the total cost to a library for a 50-year system life, a fiche collection of 20,000 titles can be compared with an equivalent book collection costing an estimated $612,000 over a 50-year life system, as follows:

	50-Year System Life for 20,000 Titles Market:		
	300 Sets	750 Sets	2000 Sets
40x	$125,717	$120,669	$118,566
80x (at high est.)	183,027	171,845	167,186
115x	172,006	163,845	160,445
150x	167,927	160,751	157,761

These figures have been computed to include costs of publishing (both fixed and incremental costs), royalties (at $1 per title), cataloging and furnishing book catalogs, marketing, acquisition of readers, and provision of reader space. However, one must realize that these figures do assume that our hypothetical publisher is operating on a nonprofit basis, a condition not likely to occur.

In concluding this review, which in no way does justice to the development presented in Appendix A, several secondary issues need some additional comments. The dual problems of duplication of holdings in a "core" collection concept and the identification of the actual market size (number of sets) are amenable to simple marketing strategy. Certainly portions of the collection could be developed to appeal to markets outside that of the small college. The point of emphasis is that there is room to maneuver if dollars per title, in comparison with that of hardcopy, is the sole criterion. Of course, it is not. Value elements such as royalties, permissions, profit and risk, together with systems demands for effective utilization all play a role, but do not defeat the overall cost conclusion: ultrafiche, in any reduction ratio, assuming a "core" collection concept, is economically attractive.

USER PERFORMANCE AND FATIGUE CHARACTERISTICS

These two studies were undertaken in order to scope or dimension how well a student could perform the essential user function implied in the educational application of ultrafiche: that of reading with comprehension. This was not the only function (of concern), but it provided an excellent starting place. In these studies, and all others discussed later, two decisions were enforced. The student must have had at least two hours of reader contact before his performance or response was considered valuable (an experimental design problem), and each experiment was balanced for equal participation by boys and girls. No faculty, staff, or graduate students participated, and each subject was paid for his efforts. All experimentation was conducted in the same laboratory with the various performance measurements recorded remotely. In the two studies reported below, little subjective work was done because these experiments were needed in order to frame useful questions.

Reading Skill-Levels on Hardcopy and on Microform Presentations

In considering the question "To what extent are the reading skills of students preserved when utilizing microform presentations?" an experiment was designed to study student performance when reading high quality materials.[1] Of concern was the problem of information loss with high reduction ratios which might seriously impair the students' ability to read from screen presentations with the same understanding and speed that is achieved with original hardcopy presentations. The three variables in the study were: reduction ratio, material difficulty, and the individual students. It was expected that at some point in the reduction range, performance would degenerate on the difficult materials, on both difficult and easy materials, or that there would be no effect and reading skills would be maintained throughout.

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[1] This experimentation is reported in detail in Appendix B. The results and methodology will be reported at the National Meeting of The American Society for Informations Science October 1-4, 1969 (San Francisco, California).

Twenty single-page monographs were used in a pilot study to differentiate two discrete ends of a difficulty continuum, to determine if and how reading rates and comprehension correlated, and to obtain profiles on the articles for central tendency, variability, and correlation coefficients for reading rate and comprehension level. Eight students (Freshmen and Sophomores from the College of Arts and Sciences at the University of Denver) read all 20 articles in random order; 20 measures of reading rate and 20 of comprehension level were obtained for each of these students. This pilot study indicated that the articles used could be behaviorally differentiated and that some articles from the opposite ends of the performance distribution were significantly correlated.

From the encouraging results of this pilot study, a full-scale experiment was designed to answer the basic question of maintaining reading skill when moving from hardcopy to screen presentation. Monographic materials (100 articles) were screened and 45 prepared for further student evaluation; of these, 25 were eventually reformated into highly readable, single page presentations (11-point Press Roman Type, 34-pica line width, 2 points of leading) for microfilming; identical copies were prepared on low reflectance stock for final hardcopy evaluations.

In determining the final 18 articles to be used, seven students were tested on the hardcopy for all 25 monographs that had been formatted for microfilming. The average scores for the 18 most highly differentiated articles were 280 words per minute with 84% comprehension for easy materials, and 240 words per minute with 66% comprehension for difficult materials.

A separate group of 12 students participated in the experiment using the readers. Nine difficult and nine easy articles were read by each student on readers at 38x, 115x, and 150x magnifications, from fiche prepared at these same reduction ratios. Average scores for the 12 students reading from fiche, for all readers, was 280 words per minute with 84% comprehension for easy materials (the same as hardcopy) and 253 words per minute with 66% comprehension on difficult materials. There was significant difference between difficult and easy materials, and between skill-levels of individual students, but no significant difference associated with the three readers used at the three magnifications, so that it was concluded, for the materials and readers tested, there were no critical points in the reduction function affecting reading skill-levels of the students.

The scores of students reading hardcopy and of those reading fiche were very close; therefore, the experiments were further analyzed. Less than 10% of total variance in comprehension determinations resulted from differences between students, and 30% of total variance resulted from difficulty of articles. However, with reading rate, 50% of the total variance resulted from differences in students, which comments on the range of reading rates these students brought to the experiment. This suggests that comprehension is a more stable indicator of group characteristics than is reading rate.

There are many things to consider in making comparisons between the performances of students using hardcopy and microform: readability, material difficulty, motivation, comprehension, intelligence, timeliness, and others, plus the various combinations of interrelationships between these factors. Inasmuch as this study evidenced stable performance in each of its manifestations, it is postulated that the participants addressed the experience in a stable motivational state: both the literature and other experiments show that comprehension questions are responsible for this stability. Greater differences in reading rates between the individual students resulted with easy than with difficult materials, which was the first suggestion that task difficulty goes far in controlling the level of awareness of an individual to environmental distractions.

This experiment was performed only to answer the question, "Can a student's skill-levels be maintained on microform presentations?" and the answer has been affirmative at all reduction ratios. This experiment did not treat the problem of maximizing the man-machine interface, and the participants apparently had the appropriate motivational set to perform a substantive task. With a different motivation and with less favorable environmental situations conducive to performance, the question of maintaining the reading skill of college students using microforms might not be answered as positively.

Fatigue Associated With Ultrafiche Use

An experiment was designed to determine student performance when involved in a continuous ultrafiche reading experience, and to discover the signs of fatigue associated with use of the medium. Material for this study was the first 50 pages of Mark Twain's Huck Finn, selected because it was considered generally interesting, and the reading itself is not difficult yet reflects a range in content from narrative, to description, to dialect; it was believed to represent a substantial class of reading demanded of college students.

The concept of fatigue as it relates to reading is developed in Appendix E. Subjective fatigue relates to an individual's feeling that he is tired and unable to perform, whereas objective fatigue relates to a performance decrement following repetition of stimulus or response. Reading is a complex process involving cognitive activity as much as physical constraint; it is a thoughtful process embracing all higher mental processes: evaluating, judging, imagining, reasoning, and problem-solving, and fatigue in reading is as much mental as physical. Concerning physical aspects, to the extent that activity is determined within the individual, it can continue for great lengths of time, but, where the way acts are to be performed is determined outside the individual and imposed upon him, there is likely to be conflict between the demand (for which an individual would have had his own natural response) and the manner of performance externally imposed on him; there would most often be a discrepancy between these two. Subjecting an individual to externally imposed requirements is demanding of him a more difficult order of organization within the neuromuscular system than when he is free to manifest randomness in his responses determined within himself.

Reading, in all situations, externally imposes certain restrictions upon people in their information gathering; further restrictions are imposed when a machine for reading is inserted into the communications channel of person and information symbology. Using microforms, subjects must manuever the images from page to page, they must often adjust the machine focus and "fiddle" with it for a best possible image, and they must maintain an almost stationary physical position "connected" to an emplaced reader, all of which are bases for disorganization of mental processes and eventual fatigue.

Fatigue can be shown by a performance decrement, a behavorial change, or both. A loss of efficiency can be concealed by change in methods of completing a task, and even in a progressive increase in output resulting from the compensatory response of a subject to his fatigued condition. The motivation that is brought to a task will control the compensation effects brought into play as a subject becomes fatigued--such compensation effects can be modified externally by adjusting goals and rewards.

The experiment here reported involved 12 students with previous reader experience matched in pairs in terms of previous average reading rates. Group I (6 students) were told they would be questioned on the reading; Group II (6 students) were not informed there would be questions. Three students from each group performed the reading on a highly readable presentation at unity blow-back ratio, while the other three students from each group used a presentation degraded three steps in readability (see Appendix C) and with a positive blow-back of 1.25 to 1.00. The students did not move about or have any means for image quality comparison during the test, except their recollection of past experience in other studies. All students completed the reading, there being no total breakdown in task performance during the reading of the 50 pages by any student (nobody quit).

Overall, there was a basic increase (average of 35%) in reading rate in this study as compared to the monographs. This was expected from the relatively easy fictional content of the material.

During the analysis of results of this work the descriptive terms "Study Group" (Group I, anticipating questions) and "Pleasure Group" (Group II, not expecting to be questioned on the material) emerged. The Study Group read more slowly for greater comprehension and retention than the Pleasure Group, showing a different motivational set in meeting the task. Reading rates from page to page showed a much wider range with the Pleasure Group as students slowed down or speeded up in accordance with their interest in the story or particular passages they wished to read or to skim. The Study Group showed a generally slower but much more even reading rate from page to page throughout the session although this group also responded to the story content. Both groups tended to increase in reading rate as the experiment progressed, particularly as it drew toward a close. Familiarity with the characters and the style would somewhat ease the reading burden as time progressed, but, more particularly, the students' fatigue, essentially physical and objective, caused many to change from reading to skimming (evidenced by students' exceptional and widely fluctuating reading rates on different pages during the last half) so as to complete the assignment. This process was evidenced by both Study Group and Pleasure Group, although to the greater extent by the latter.

Those students using the presentation of a degraded image showed a depressed reading rate initially, but apparently adapted quickly so that the use of both good presentation and degraded-image presentation were essentially equivalent after the first five pages.

In questioning the students as to their subjective feelings of fatigue, 7 of 12 said they were tired and another said his eyes were tired but he wasn't tired physically. Those 4 who did not "feel tired" thought it was because the story was interesting and held their attention. In response to a question as to why they didn't quit, 9 of 12 said they didn't feel like giving up and 3 said they would have but feared they wouldn't get paid.

Both subjective and objective aspects of fatigue were present in this experiment, as they appropriately should be; the question is whether or not there was indication of greater fatigue using a reader presentation than would be expected using hardcopy. In terms of objective fatigue, two levels of performance are evaluated which show no behavior that is inconsistent with what could be expected with hardcopy; further, nothing in the results suggests that different performance might be obtained; there was no total breakdown of task performance on the part of any student, and the comprehension of the story (tested most thoroughly on the last part of the reading) showed that all students were, at the finish of the task, still maintaining their comprehension levels associated with this class of material. Subjective fatigue, however, is an entirely different situation; the presence of the machine does create new constraints in that the student is subjecting himself to externally imposed requirements demanding a more difficult order of organization within the neuromuscular system, and the imposed requirements are reflected in the students' comments about quitting. One might not expect that 3 of 12 students would have wanted to quit if they had been using hardcopy and been free of the machine interface.

Focus on the total environment of reader presentation would bear on subjective fatigue; a human factors analysis which integrates the total task: reader machine, user, environment, would lead to minimizing the imposed requirements. It is clear that performance can be obtained if motivation is present; the design challenge can be seen as performance sustained through satisfaction of personal information needs, or "unstructured motivation."

FACTORS AFFECTING USER ACCEPTANCE OF MICROFORM

The results of the performance and fatigue studies were satisfying in that, for reading at least, the student could perform at appropriate levels for useful lengths of time on available reader equipment. At this point, we were experimentally disinterested in distinguishing between high and low magnification readers; rather the differences in overall presentation quality, or operational characteristics were obviously more important. In terms of potential applications, these experiments indicated that student motivation must be high in order to sustain use and, in practice, the students' information needs must supply that motivation. This is too much to expect if routine use is implied in an application. This awareness prompted a detailed investigation into the factors that control acceptance of microform, the mechanism for creation of negative attitudes, and behavioral response to other types of tasks that may be encountered in educational microform use.

Acceptance of Educational Microforms

Effective use of microform systems in education depends on the satisfactory insertion of a man-machine interface into the communications channels that are presently well developed in the educational environment, so that the student can, and will, use machine presentations routinely. But to expect routine use at this juncture is folly; the only experience base within the college relating to microforms has to do with exceptional materials: out-of-print works, back issues of periodicals, etc., all appealing to the limited audience in need of such items. It has been stated that use of microforms in research libraries is generally unsatisfactory and such experience has only negative significance in that it merely identifies areas of frustration and failure. Commercial uses have little relevance because their demands are "data--search" oriented (rather than "concept--study" oriented) and the motivation for use stems from employment where use is part of the job. In education, motivation for use stems from a student's perception of his educational goals. The attitudes formed by users relative to microform presentations are pivotal to their routine acceptance by the average undergraduate in a university.

It was recognized early in this program that user dissatisfaction with microforms was always expressed in terms of discrepancies. An individual recognizes something is wrong in a process when he knows there is a relevant alternative process, and he knows something about the characteristics of that process. The student user sees any microform presentation as a hardcopy substitute (the relevant alternative) but he has never had to identify characteristics of hardcopy. Negative attitudes develop thru comparing specific characteristics of hardcopy (which are newly discovered) with the new process of film and screen; the discrepancies surrounding the presentations force the discovery so that a model develops in the user's mind of what the presentation should be, a model that matures as both contact is increased and difficulties are encountered.

Since the user finally sees microform presentations in terms of his hardcopy model, discrepancies encountered might relate to equivalence (where the mediums should be alike), accommodation (where physical differences affect the relative ease of task accomplishment), or adaptation (where there is a system or environmental dependency). To identify critical user acceptance factors, experiments were undertaken relative to discrepancies in all three of these classifications (see Appendix F).

Three studies were performed to discover performance dependency thru contrast in presentations. The reading materials were monographs as in the initial Performance Study (Appendix B) and in each of the three studies eight different students participated. In each study the students were exposed to two readers, two classes of material difficulty, and a total of 16 article presentations. The two readers gave presentations with differing characteristics involving the screen, the fiche, focusing, and brightness levels (but not readability).

In one experiment, the articles were presented first as two easy and two difficult for each trial (4 trials), each new trial on the alternate reader. The next study presented one easy and one difficult article for each trial (8 trials), each new trial switching to the alternate reader. Last, all eight articles of the same difficulty level were presented in sequence, followed by all eight articles of the other difficulty level, with two articles per trial (8 trials), each new trial on the alternate reader. All studies were stabilized with comprehension questions.

The two readers used in the equivalence (or contrast) experiments had differing discrepancies in terms of hardcopy equivalence.

The hypothesis was that no difference in performance would result from their alternate use and, overall in the first experiment this hypothesis could not be rejected. However, an analysis by class of material difficulty showed a cyclic pattern of performance between the two different presentations for the "easy" material. Under the experimental conditions of this study, there was a performance difference between the contrasting presentations that was dependent on demands made on the user by the material difficulty.

It was then reasoned that the differences in presentation would become more apparent with more frequent encounter. The second study doubled the number of presentation cycles from four to eight. As expected, this forced the comparison; analysis of results showed a significant presentation effect in terms of performance for both levels of material difficulty. It was concluded that in the absence of highly contrasting presentations, repetitively seen, sensitivity to presentation differences is controlled by the demands that the materials make upon the subject. In the last study of this experiment, all material of a single difficulty class was sequentially seen, with four contrasting presentations, and then all material of the remaining difficulty class. Now, the effect of contrasting presentations on reading ability disappeared although the difference in reading rates across material levels was preserved. It appears that students, under these circumstances, perceived all of the material as difficult.

It is clear that initially the individual is not aware of discrepancies in presentation; opportunity for contrast expedites the development of his own unique model for a suitable presentation. Further, the perceived difficulty of the reading task controls awareness of outside stimuli. A subjective critique of presentations made by the subjects in these contrast experiments led to the concept of discrepancies being either reinforcing (those calling attention to themselves as each frame of information is presented) or non-reinforcing (those which may cause an initial reaction but which diminish in importance with time).

To study accommodation aspects of microform use, the student's ability to "search" a complete 500-page title was considered in an experiment where the materials included tables, charts, graphs, indices, and various lists. In conjunction with the actual search, the participating students were able to establish their views of appropriate reader position, screen angle, screen brightness and ambient illumination. Several periods during the experiments were utilized for subjective comment about the tasks and about the readers by the students. There were 43 search tasks in the study, in addition to 20 more tasks which were used as a "warm up" or conditioning. These tasks were each identified in three ways: with the concepts of (1) abstracting information from text, figure or table, or supplementary data in the material; (2) location, whether directly indicated by index aids, or whether the searcher was only generally directed to the data source; and (3) indexing which required use of an information source aid to locate the data, or conversely, where the student could go directly to the material without using some index guide. The responses to the tasks were timed for varying patterns of performance of search tasks involved in the "studying" of educational materials. The search was difficult; both project staff and students found it tedious. The students divided into two main groups: (1) quick and accurate, (2) slow with poor results, and into a transition group composed of (3) those fast but with poor accuracy and (4) those slow but accurate. With all students, speed was improved between the warm-up portion of the experiment (20 tasks) and the actual study (43 tasks).

It was concluded that a range of specific tasks germane to a student's use of microform could be performed on a high-magnification, high-density, reader-fiche combination. The search tasks of the experiment were "real work" as compared with readings. The principal recommendation resulting from this study was that there be vertical placement of frames on a fiche so that the dizziness and discomfort associated with motion and overshooting a page is reduced and the critical, precise frame positioning of every page is eliminated (only columns would thereby need to be framed since vertical advancement of fiche would keep full lines of information always in view).

Environmentally, a subject orients the reader so that his eyes are vertically in the screen's center, with screen parallel to his face when in a writing position. There is strong requirement for reader mobility forward to and backward from a subject during prolonged use to permit body position change--there is a moderate range in the distance tolerated between screen and eyes which is not sufficient for necessary body shifting during use; the reader should accommodate this by its mobility. Generally, those students who sat down and attacked the job wanted high screen brightness, whereas those who reluctantly tolerated the task wanted much lower screen brightness; variable illumination is, therefore, important in reader design to accommodate the varying motivational set of different students and each student at different times.

A frustrating task such as this search quickly forces the student to compare differences between books and screen presentations in terms of the total task. Search was considered by all to be a much more difficult process than reading and gave rise to the first positive comments about microform, i.e., your hands are free when working from a screen.

The same students involved in the search study were used in an adaptation study involving preferences of reader-fiche combinations (after assurances that the performance they would give would not involve further search-type tasks). Now the students were asked to read four short stories, one on each of four different readers, and then were asked to select one of the readers on which to read two more stories. It was hoped that preferences would have identifiable patterns and the basis of preferences could be determined; that the range of presentation difference might provoke a common response. Comprehension questions were used in combination with all readings as a stabilizing or motivational influence.

The results of this study indicated no one presentation was generally selected by the 11 participating students as being the most desirable, but the reader demanding careful frame positioning was totally rejected. Each of the three readers selected by the eleven students were selected for the same attributes, i.e., each student thought his selection was the reader that maintained best focus, was easiest to use in framing images, had the best fiche maneuverability, and, once his selection was made, then his overall performance index increased measurably.

Comprehension questions designed to study if thought continuity was interrupted during the process of frame advance disproved this concept. On the question of polarity, the negative image was definitely preferred on the reader which had the more noticeable "hot spot"; where this illumination gradient over the screen area was less severe on an alternate reader, the students were divided in their opinions as to whether positive or negative was preferable.

These experiments relating to the acceptance of microforms in higher education represent only a beginning exploration of a complex problem. Acceptance is, first of all, controlled by the value of the information to the user. The concept of discrepancies forcing a comparison of the screen medium with its alternative hardcopy is viable for any particular user task. Meaningful use minimizes the user's awareness of presentation details but trivial or frustrating use maximizes awareness of discrepancies in presentation.

IMAGE QUALITY: ESTIMATION AND PREDICTION

Image quality in microform presentations has always caused concern to people involved with their production; some information contained in hardcopy is lost in the transfer to microform. This loss is occasioned both in the photographic reduction and in the reader magnification processes, so that in general, the information loss increases with reduction ratio. However, there is not a direct relationship between the conventional meaning of legibility and loss of information; a considerable loss can be tolerated before an effect is observed in reading skills.

To promote both the descriptive and comparative requirements of this program a method of determining image quality was needed. A technique by Harold J. Fromm, being explored by Kodak and suggested by their representative, was chosen to fill this requirement. The technique involves a random grain pattern step tablet, operating on the principle of variable signal-to-noise ratio. Text is read thru the step patterns and a determination made by the viewer of the step beyond which the text cannot be read. Appendix C shows examples of the pattern used in evaluating materials during this program.

For our purposes, readability and visibility determinations were separately made on test materials. Readability was defined as the highest step in the pattern thru which text could be read without hesitation. Visibility was defined as the highest step thru which individual characters, as opposed to complete words or groups of words, could be recognized with assurance. Since this technique is essentially subjective, several evaluators were required to establish a consensus.

The grain pattern was used as a quality indicator for each of the studies in which students were interacting with the reading machines, both as to the hardcopy original materials and the reader images. Several observations were made during these analyses: it was possible to improve readability thru microform presentation, a result associated with high screen brightness; positive blow-back improved readability at low reader magnification, but degraded readability at high magnification as a result of contrast failure; material with exceptional legibility in hardcopy form has a consistent readability at all reduction ratios tested.

The grain pattern was used by a single evaluator to qualify the library sample materials as to visibility. From these data an approximate linear regression equation was developed showing a visibility index related to contrast, type size, stroke width, and stroke spacing:

$$\text{Visibility index} = -9.39 + 7.45c + 0.46t + 0.27b - 0.13s$$

where:

c = difference in reflection density between print and background

t = type size, in points

b = stroke width of small "e" bar (0.001 inch)

s = stroke spacing within "e" (0.001 inch)

Other factors which play a part in image quality were ignored at this point in developing the simple equation above.

Other test materials were selected and filmed representing typographic variation to be evaluated by the random grain pattern technique. These materials were ranked for both visibility and readability. Results indicate that the grain pattern can be used to predict image readability with some few qualifications. Information loss, increasing with reduction ratio, is evidenced by decreased visibility: this decrease depends on a balance of typographical factors that affect image visibility differentially. Visibility, therefore, may not be the appropriate criterion for judging image quality or predicting quality based on hardcopy evaluations. In making hardcopy duplicates from microforms, it is important that high visibility be preserved; however, it would be expected that most high density microforms in education would be concerned with image readability as found on a reader screen, and this readability quality is well preserved in present technology. While high visibility is indicative of high readability, the converse is not necessarily true; readability in the educational application may be considered the better measure of image quality.

The visibility and readability determinations made with the random grain pattern appear to be broadly useful as a measure or index of image characteristics, but the need for serious research is only emphasized by this modest experimentation.

It might be observed that microform applications in the past have been concerned, to a great extent, with materials which by their nature, content, and purpose, are dependent upon individual character recognition, or, in accordance with our thesis, a high visibility index; when this has not been successfully accomplished during the information transfer to microform, the medium has been viewed with important reservations. However, the essential purpose of educational microform is consistent with high readability of screen presentation. If the ability to reproduce high quality hardcopy were a prime requirement, then visibility would be the key index: but hardcopy recreations from the ultrafiche are only incidental to the application.

CHARACTERIZATION OF A COLLEGE LIBRARY

The physical nature of existing library materials is pertinent to any effort contemplating microform publishing of educational materials; books as they currently exist in libraries represent the reservoir for any such immediate endeavor to utilize, substantially, the film medium for education. A study was undertaken in this program (see Appendix D) to dimension the library for systems design or microform manufacturing. A significant store of data was tabulated in the sample of materials taken from the University of Denver Libraries. Every 487th card in the shelf list was noted and the corresponding volumes were used in developing the library characterization statistics. Some of these data, such as distribution of book lengths and page sizes, basic differences in old versus new materials, and typographical information relating to image quality, were needed for this study. The statistics developed could relate to various decisions regarding fiche organization, reader development, reduction ratios, etc., depending on the purpose to be served in a microform publishing project.

During this study 396 titles were characterized in this manner; the data was placed on punch cards, and a computer print-out run off. The results of this work have been only partially studied from the viewpoint of system design and typography considerations. In terms of utility, a comparison of publication dates and book lengths was made between the Fondren Library of Rice University (from a sample previously taken there) and the University of Denver Libraries; the general distribution patterns were very similar.

A frequency tabulation relating height and width of information areas in the sample volumes indicates that a reader screen of 6 by 9 inches would accommodate one-to-one presentation of about 93% of the titles sampled. This observation reflects on reader design in terms of size, illumination, heat, and optics. Certainly this is the most significant single result obtained since it suggests that a small reader is consistent with the information base.

The random grain pattern technique (see Appendix C) was used on all books in the library sample to determine its operation as a typographical evaluator. Four typographical characteristics, contrast, type size, width of stroke, and space within letters, were used for development of an approximate regression equation for determining visibility. These characteristics are not inclusive of all factors operating, but it is clear that the grain pattern does integrate certain essential factors into a single evaluation. For purposes of predicting image quality, subsequent experiments suggest that readability would have been a more useful index to develop. The visibility determinations do, however, clarify the introduction of typographical factors. Many different combinations of data for the factors measured can be developed to serve specific purposes or answer specific questions. This was the objective in creating a data base that makes available both system information and typographical information from a single sample.

SUMMARY AND FUTURE WORK

The total experience gained in performing these studies has been drawn upon in order to make specific recommendations and observations concerning improvement of reader-use interface.

First, it must be accepted that an application which demands routine and extended use of a reader presentation for communication of subtle and abstract information, for reading, and for survey work, should be supported by a reader designed for the application.

Basic to these recommendations is the concept of publishing by column instead of row.[1] Besides facilitating the location of information within the fiche and reducing the annoyance of reframing each frame (only the column need be framed and the use of detents would accomplish this), precise side to side positioning makes the use of a small screen mechanically practical. The small screen demands an excellent fiche positioning scheme in order that the advantages that accrue from small size (in terms of lamp power, heat, optical path, etc.,) are not offset by the reinforcing annoyance of poor frame control. The desire for a small screen does not depend only on the 6 by 9 inch information area found in the library book analysis: we can argue successfully that 9 and 10 point type can be projected undersize (up to 20% reduction) with increased readability. The small screen is basic to a small reader and this is the most direct attack on a major class of discrepancies. Another reason for designing around a small screen is that the students prefer the screen essentially filled with information with no large bright border areas. Material that was framed by an opaque border extending to the edge of the screen was particularly satisfying. Each of these preferences is consistent with a small screen.

Uniformity of focus over the image and maintenance of frame to frame focus should be given highest design priority: the uniformity of screen illumination is particularly important for positive images and variable lamp intensity is certainly attractive. The value of laminations on the fiche cannot be overemphasized. A family of user problems are overcome: these include fiche maintainance, durability and clean screen images.

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[1] This idea was first suggested to DRI by Dr. Klaus Otten of the National Cash Register Company.

The proposed continuation of research under Contract OEC-0-8-080826-4648 is designed to translate the focus of the educational microform investigation from the man-machine interface to the plane of operational reality as reflected by direct support of educational activity. The major point of emphasis in this translation is the environment for effective microform utilization.

The environment for effective microform utilization is an inclusive concept that considers utilization in terms of a series of system levels. At each level, the environment represents the summation of physical and pragmatic constraints which modify the effectiveness of the system itself.

The University of Denver proposes a program in which the environment will be investigated and appropriately modified for each of the following system levels: the student-reader interaction (emphasis on carrel design), the information-student interaction (emphasis on the library adaptation), and the classroom-information-student interaction (emphasis on group adaptation and a broad range of materials). The program will be developed around student users' response to information needs within realistic educational situations. The student contact points will be the classroom, the library, and the testing laboratory. A central concern throughout the program will be the involvement of both equipment manufacturers and publishing houses in support of this effort.

FINAL REPORT

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APPENDIX A. HIGH-DENSITY MICROFICHE AND THE ACADEMIC LIBRARY: AN ECONOMIC ANALYSIS

July 1, 1969

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U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Division of Information Technology
and Dissemination

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HIGH-DENSITY MICROFICHE AND THE ACADEMIC LIBRARY: AN ECONOMIC ANALYSIS

PURPOSE, SCOPE, AND METHOD

This Appendix provides an assessment of the potential impact of high-density microfiche upon the economics of the academic library. The Appendix is a summary of a detailed report to be published separately by TECHNOMICS, Inc. The economic analysis was conducted under a subcontract to the Denver Research Institute as part of the study, funded by the U. S. Office of Education, entitled "An Investigation of the Characteristics of Ultrafiche and Its Application to Colleges and Universities."

Three Models

Three models were developed for the economic analysis. The first was formulated at the request of the Bureau of Research, U. S. Office of Education. It explores the development costs and potential economic effect of a core collection of 20,000 titles in fiche, introduced into the academic library as a package.

The second hypothetical model considers the production and handling of single titles in fiche, as distinct from large collections. The development of this model was motivated by three assumptions: First, that an alternative to the core-collection model would provide useful perspectives. Second, that if a core collection in fiche were in fact established in a library, keeping it up to date would require a method for making incremental changes. And, third, that the single title is the basic working unit of libraries and the publishing industry, and therefore offers a familiar base for a discussion of an unfamiliar technology.

The third model preceded the others in time. It is a model of existing costs and functions in libraries, in the publishing industry, and in the world of library users. This model was developed from the literature and from interviews and telephone conversations with any number of patient and helpful persons who are experienced in the three subsystem areas just named. With the help of these sources, an effort was also made to consider the potential role of the library on tomorrow's campus. The purposes of the initial model were two: first, to afford a comparison for discussing the costs and benefits of the two later models; and, second, to insure that functions of the library system were not omitted, either in planning the theoretical models or in assessing their whole-system impact.

Methodology

Some three hundred system functions were identified in developing the initial model. The two theoretical models were formulated by proceeding twice through the list of system functions, pausing at each item the first time through to ask: What would be the effect at this point of introducing a package of 20,000 books in fiche?--and pausing the second time to ask: What would be the effect here of introducing a fiche instead of a book in paper? At some points (with the single-title model, in particular) no differences were inferred; at others (especially with the core-collection model) wholly different system schema were indicated. Where differences appeared, costs of the present-system model were obtained from the literature or from interviews; comparative costs for the theoretical models were developed as will be described in the sections to follow. Some of the theoretical costs stem from the findings of the Denver Research Institute; others are extrapolations of existing costs for a given service or process, and still others are wholly conjectural.

It has further been assumed that both theoretical models are directed to a library possessing no more than 40,000 titles in its present collection and serving a student population of 600. These numbers are derived from a 5% sample drawn from data provided in 1966[1] by 1,891 academic institutions (out of the 2,207 listed in the U.S. Office of Education's Education Directory, 1965-66, Part 3, Higher Education). The sample indicates that in 1966, 40% of the nation's academic libraries--80% of the junior colleges--had fewer than 40,000 titles in their collections. The median student population of the group was close to 600. The cut-off at 40,000 titles is high enough to include an important number of libraries, yet low enough to suggest that the institutions in this class face serious problems in building collections.

Persons from 133 other organizations contributed information, guidance, and other help to this project. They were contacted by visit, by letter, and by telephone. These people represented colleges and universities, the microfilm industry, publishers, printers, consulting firms, manufacturers of data processing systems, government agencies, and assorted institutes, centers, councils, and associations. The working bibliography for the project comprised 203 titles, plus manufacturers' publications and price lists.

The material to follow in this Appendix is in four sections. Because both theoretical models employed in this study draw on information relating to the costs and prices for manufacturing fiche, a section devoted to that subject appears next. It is followed by a description of the single-title model. Then the core-collection model is described. The Appendix closes with a brief statement of the conclusions drawn from the study. The present-system model is not separately described in this Appendix, but elements are drawn from it as needed for purposes of illustration and comparison.

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[1] American Library Association, Library Statistics of Colleges and Universities, 1965-66 Institutional Data, Chicago, Illinois, 1967, 234 pp.

THE FICHE: FORMAT AND PRICES

Parameters for the Price Models

Figure 1 pictures the basic fiche format assumed for the cost calculations to follow. The fiche size is 4 x 6 in. This is the size employed in the user experiments at Denver Research Institute. No effort was made to assess alternatives, such as a fiche of 3 x 5 in. or of tab-card size. Across its top, the fiche carries a 1/2-in. band for an eye-readable label. A 1-in. strip at the left side provides for machine-readable coding, against the day when mechanical systems are introduced for filing and retrieval. Part of this strip can also be used for the fiche's internal index. A 1/8-in. margin is provided at the remaining edges.

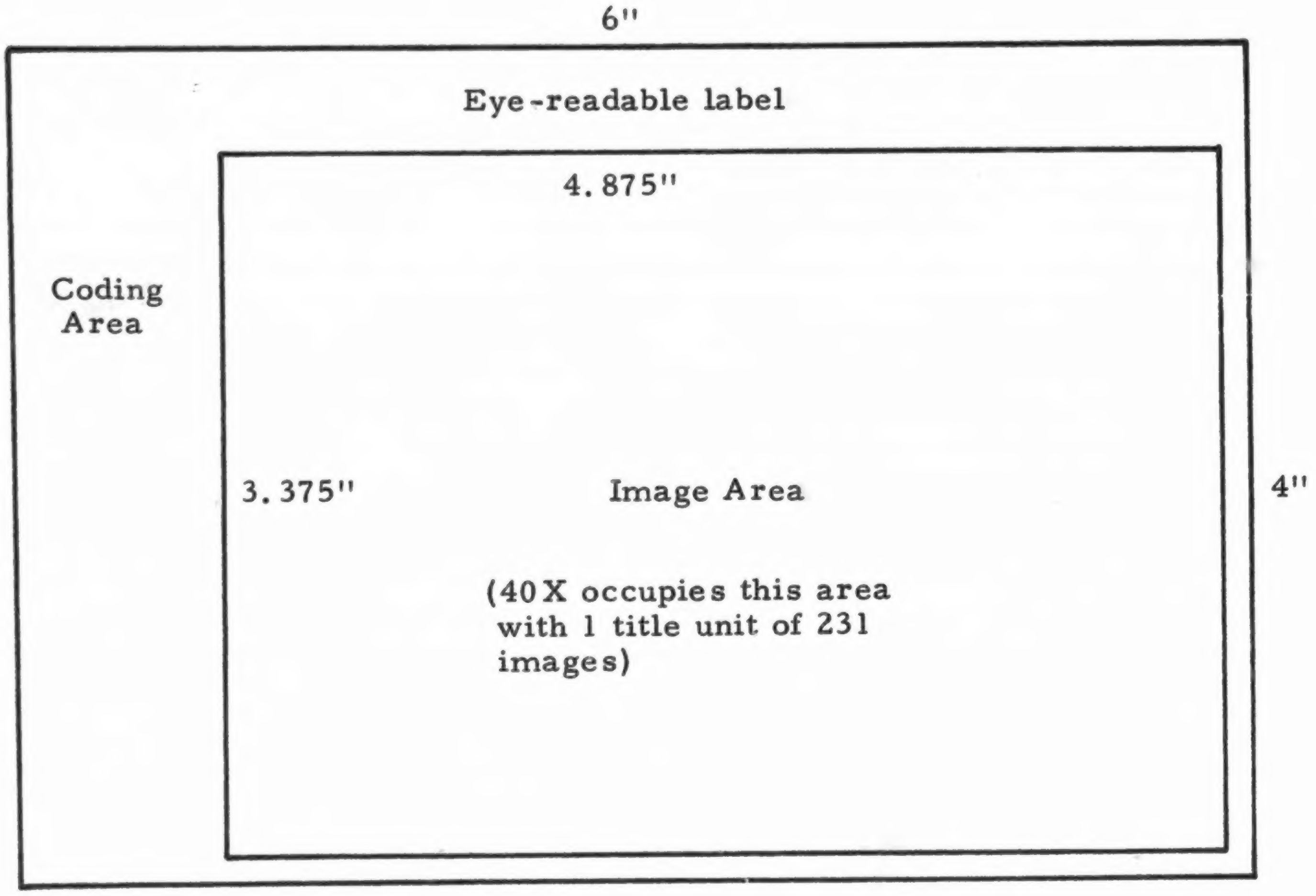
Three reduction ratios have been dictated by the fiche used in the research carried out by Denver Research Institute: 40X, 115X, and 150X. A fourth ratio has also been introduced in response to the interest that has developed in the last two or three years in the concept of a "library fiche," carrying 300-500 pages of information, meant specifically for book publication. Such a fiche, if held to the 4-x-6-in. size, would require a reduction of 50 diameters or more, depending on the usable film area and on one's judgement about the sizes of original material to be accommodated. No off-the-shelf system for microfiche is presently available between 38 and 100X. The DRI staff have asked for an estimate of fiche costs in this mid-range, and have suggested a reduction of 80X, which approximates the halfway point between 40X and 115X.

Table I translates the given reduction ratios into fiche capacities in images. A target size of 9 x 12 in. is assumed. This will accommodate upward of 85% of books and serials, including many European periodicals. It will also permit publications in music.[1]

At the higher reductions, economic use of a fiche requires that it hold more than one title. In this study, we have assumed that title units will be blocked off on the face of the fiche. The formats are shown in Figure 1. The decision to use one unit at 40X, two at 80X, four at 115X, and eight at 150X was arbitrary, but it results (except at 40X) in title units that are roughly comparable in terms of images per unit. Table I displays the capacities of the resulting title units.

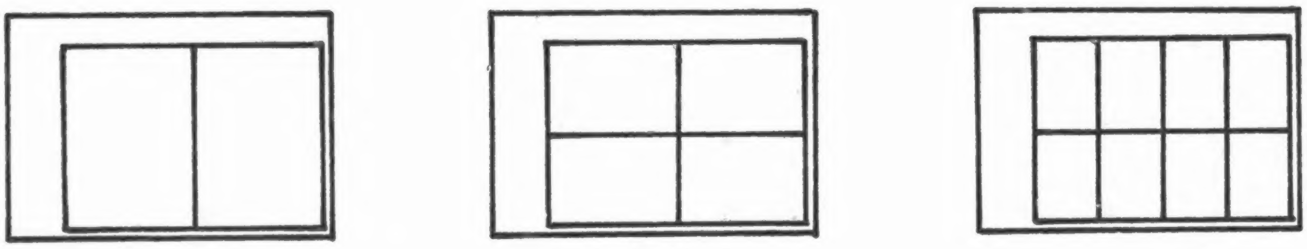
---

[1] A 7-x-9-in. target size will yield savings in fiche if books alone are considered. The 9-x-12-in. size is advocated by William R. Hawken, "Microform Standardization: The Problem of Research Materials and a Proposed Solution," NMA Journal, Fall 1968, 22.


6"
Eye-readable label
4.875"
Coding Area
3.375"
Image Area
(40X occupies this area with 1 title unit of 231 images)
4"

BASIC FICHE FORMAT

FORMATS AT DIFFERENT REDUCTIONS



80X Format

2 Title Units
462 Images in Each Unit
924 Images Total

115X Format

4 Title Units
496 Images in Each Unit
1,984 Images Total

150X Format

8 Title Units
420 Images in Each Unit
1,360 Images Total

FIGURE 1: FORMATS

IMAGE SIZES:

Original		40X	80X	115X	150X
Width:	9"	.225"	.1125"	.078"	.06"
Height:	12"	.3"	.15"	.104"	.08"

NUMBER OF IMAGES PER FICHE:

Film Area		40X	80X	115X	150X
Width:	4.875"	21	42[*]	62	80[**]
Height:	3.375"	11	22	32	42
Total		231	924	1,984	3,360

NUMBER OF IMAGES PER TITLE-UNIT[***]

	1 Unit; 40X	2 Units; 80X	4 Units; 115X	8 Units; 150X
Columns	21	21	31	20
Rows	11	22	16	21
Per Unit	231	462	496	420

---

[*] Fiche will hold 43 columns; 42 are shown here to permit division into 2 units.

[**] Fiche will hold 81 columns; 80 are shown to permit division into 8 units.

[***] Formats are shown in Figure 1.

TABLE I. FICHE CAPACITIES

A sample of books from the Denver University library, arrayed by number of pages, has produced the curve of cumulative percentages shown in Figure 2. Only the points shown (◆) were plotted from the sample data; these points were linked without further calculation to produce the curve. Values beyond 800 pages were extrapolated, as far as 2,728 pages, the size of Webster's Third New International Dictionary.

By using this curve, one can estimate the number of titles in a collection of 20,000 that will require one title unit, the number that will require two, and so on. Title units of 231 pages (for the 40X fiche) are marked off on Figure 2 to illustrate the process. Similar exercises were performed for the title units used at the other three reductions. These quantities in turn permit one to estimate the total requirement for fiche of a given kind, as shown in Table II. The sample data from the Denver University library show an average of 326 pages per title, which provides an estimate of 6,520,000 pages for the hypothetical collection of 20,000 titles.

The findings of this inquiry into prices for manufacturing fiche and masters are summarized in Table IV. The values shown there represent expected costs of a publisher for having 20,000 titles filmed, masters prepared, and fiche run off in given quantities, from 25 to 3,000. A brief discussion of these estimated prices is offered in the following sections.

Sources and Assumptions for Estimates of Filming Prices

Filming costs for low reductions are buried in inclusive charges for preparing master fiche and are not available at all for high reductions, since manufacturers prefer to quote on high-reduction filming only in terms of specific jobs.

But one can call upon experience in other areas for guidance. The price schedule for microfilm of the Huntington Library, in San Marino, California, suggests that a per-image cost of $0.05 for routine material and $0.10 for problem matter would not be inappropriate.[1] The Huntington houses one of the world's great collections of old, rare, and valuable materials. While those prices are higher than the prices that prevail in the business community for microfilm services, they commend themselves to our purposes for two reasons: First, because filming for high-reduction fiche will be more exacting than filming for conventional reductions; second, because some part of the reputation

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[1] For "regular material," the Huntington charges $0.08 each for the first 200 exposures and $0.05 thereafter. For "material requiring special handling," the first 200 exposures cost $0.12 each; additional exposures are $0.10. An exposure may accommodate two pages. The two higher figures defray the fixed costs of set-up and materials. Spool, box, packaging, and mailing are extra.

40X

Title unit: 231 images
Title units per fiche: 1
Fiche capacity: 231 images

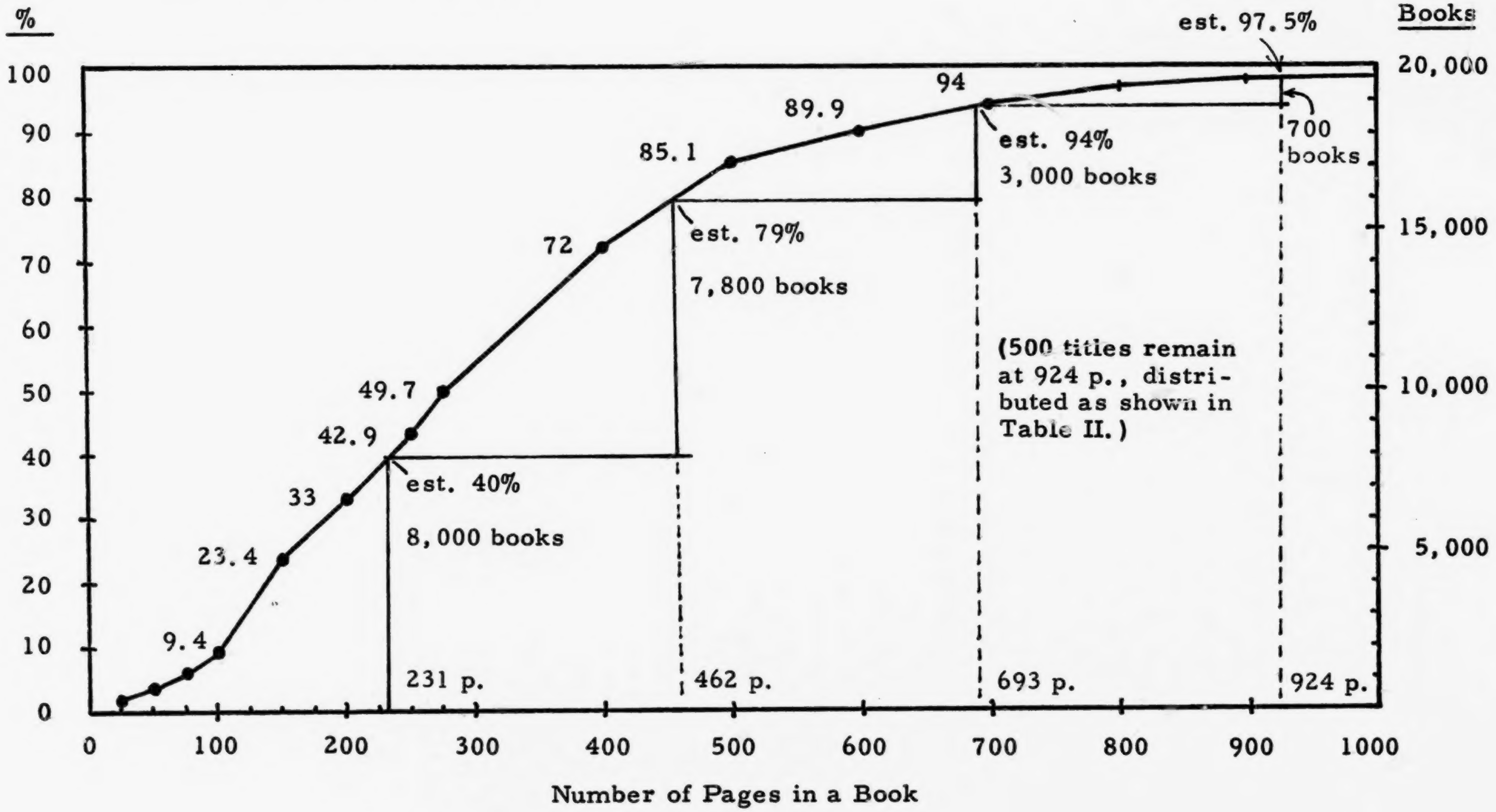


FIGURE 2. CUMULATIVE % OF BOOKS AT GIVEN PAGE COUNTS

40X Unit: 231 images; 1 unit per fiche.

Pages	No. of Titles	No. Per Fiche	Fiche Needed
0-231	8,000	1	8,000
232-462	7,800	.5	15,600
463-693	3,000	.33	9,000
694-924	700	.25	2,800
925-1155	200	.20	1,000
1156-1386	100	.167	600
1387-1617	33	.143	231
1618-1848	33	.125	264
1849-2079	33	.111	297
2080-2310	33	.10	330
2311-2541	33	.09	363
2542-2772	33	.085	396
	19,998		38,881

115X Unit: 496 images; 4 units per fiche.

Pages	No. of Titles	No. Per Fiche	Fiche Needed
0-496	17,000	4	4,250
497-992	2,600	2	1,300
993-1488	200	1	200
1489-1984	67	1	67
1985-2480	67	.5	134
2481-2976	67	.5	134
	20,001		6,085

80X Unit: 462 images; 2 units per fiche.

Pages	No. of Titles	No. Per Fiche	Fiche Needed
0-462	15,800	2	7,900
463-924	3,700	1	3,700
925-1386	300	.5	600
1387-1848	67	.5	134
1849-2310	67	.33	201
2311-2772	67	.33	201
	20,001		12,736

150X Unit: 420 images; 8 units per fiche.

Pages	No. of Titles	No. Per Fiche	Fiche Needed
0-420	14,800	8	1,850
421-840	4,600	4	1,150
841-1260	350	2	175
1261-1680	100	2	50
1681-2100	50	1	50
2101-2520	50	1	50
2521+	50	1	50
	20,000		3,375

TABLE II. NUMBER OF FICHE NEEDED

for poor quality that has attached to microforms in general can be traced to penny-pinching work in the initial filming. For these reasons, this study has taken the Huntington prices as a floor and arbitrarily introduced two alternative values, $0.10 and $0.15, that are higher still, in order to suggest a range within which it appears reasonable to assume that actual filming prices will lie. Manufacturers have explained that if filming must take place at a library (as may be necessary with rare books), the price may go as high as $0.25 per image in order to pay for the on-site facilities and controls demanded by high-reduction work. On the other hand, there exist circumstances that would shift prices the other way. The publication of a core collection, for example, with its preponderance of recent books, would push prices downward because the materials can be expected to present good images, as a body, and will not require the care in handling that must be given rare materials. Brand-new books, filmed from unbound pages, or placed directly on film from a magnetic tape used also for typesetting, would involve a minimal filming cost. Neither extreme has been incorporated in the price estimates of this study. The values used are summarized in Table III.

40X: Prices for Masters and Fiche

Manufacturers' experience with microfilm at or near 40X has been confined to closed systems that do not conduce to generalized public statements about cost or price. But an extrapolation of current prices for fiche at 20-24X suggests that an inclusive price (filming, materials, and processing) for 40X fiche would fall in the range of $14-16. A $3.00 charge for materials and processing will yield this result, when it is coupled with the $0.05 per-image charge already adopted as the low estimate for filming. The price of a laminated fiche made from the master is estimated in this study as $0.20. It should be pointed out that because of the quantities of fiche and masters needed to carry 20,000 books at 40X, a small error in estimating prices will have a large overall effect. Table III summarizes the price estimates for 40X.

80X: Prices for Masters and Fiche

Here is another reduction ratio for which established prices do not exist. Nor can any manufacturer point to commercial production experience at or near 80X to provide guidance. And yet it has seemed clear that 80X in all its technical particulars--film stock, camera work, processing, readers--would be of the same price family as the higher reductions from 100-150X. Thus this study uses estimates for 80X masters based on the prices for higher reduction fiche published by the two manufacturers participating in the experiments conducted at Denver Research Institute. One quotes a price of $100 for a high-reduction master; the other a price of $250 for a master containing 1,000 images or less--a range that accommodates our 80X fiche with its capacity of 924 images. These prices have been used in the study

Filming Prices: 6,520,000 Total Images	
80% routine @ $0.05	$260,800
20% difficult @ $0.10	130,400
Low estimate	$391,200
80% routine @ $0.10	$521,600
20% difficult @ $0.15	195,600
High estimate	$717,200
40X: Masters and Fiche	
38,881 masters @ $3.00	$116,643
Laminated fiche: 38,881 @ $0.20	7,776
80X: Masters and Fiche	
Mfr. A: 12,736 masters @ $250	$3,184,000
Mfr. B: 12,736 masters @ $100	1,273,600
Fiche: 12,736 @ $0.90	11,462
Alternative estimates at one-half the prices above:	
Mfr. A: 12,736 masters @ $125	$1,592,200
Mfr. B: 12,736 masters @ $ 50	636,800
Fiche: 12,736 @ $0.45	5,731
115X: Masters and Fiche	
Mfr. A: 6,085 masters @ $275	$1,673,375
Mfr. B: 6,085 masters @ $100	608,500
Fiche: 6,085 @ $0.90	5,476
150X: Masters and Fiche	
Mfr. A: 3,375 masters @ $350	$1,181,250
Mfr. B: 3,375 masters @ $100	337,500
Fiche: 3,375 @ $0.90	3,038

TABLE III. PRICES FOR MASTERS AND FICHE

to provide high and low estimates. For duplicate fiche made from high-reduction masters, one manufacturer quotes a price of $0.80, the other, $1.00. In this study $0.90 is used as the price of a duplicate.

As little as six months ago, these estimates based on high-reduction prices would have seemed adequate. But in the last six months, technical developments, still proprietary, have suggested that 80X may actually fall in a middle range of prices, between those established for reductions above 100X and those that apply to lower reductions at 20-40X. To reflect this possibility, a second high-low range has been established for the study--a range arrived at by cutting in half the high-reduction prices just quoted. No rationale is offered for this cutting-point, except that it serves a felt need to test the consequences of a price schedule somewhere in the middle region. The estimates for 80X fiche and masters are summarized in Table III.

115X: Prices for Masters and Fiche

One manufacturer quotes a flat price of $100 for masters at 115X; for the other manufacturer two prices apply: $250 up to 1,001 images; $300 from 1,001 to 2,100. While the 115X fiche of this study has a maximum capacity of 1,984 images, unused space will place many fiche in the $250 category. This effect is approximated by employing a flat $275 for the upper-limit estimate of manufacturing price. As with 80X, $0.90 is used as an estimated price for duplicate fiche. Table III summarizes the 115X estimates.

150X: Prices for Masters and Fiche

One manufacturer continues to quote $100; the other quotes two prices that apply to the 150X master, with its capacity of 3,360 images: $300 for 1,001-2,100 images, $400 for 2,101-3,200 images. The 150X masters will find themselves in both categories, and again the decision was made to approximate this result by basing the upper-limit estimates on a flat $350 per master. Estimates for duplicate fiche remain at $0.90. The results are summarized in Table III.

Price Summary

To better display some of the issues involved, total manufacturing prices for a package of 20,000 titles on fiche are shown in Figure 3. Only the low-estimate values were used. A clear price advantage lies with 150X, except at the very lowest production levels, where 40X prevails. But some of the uncertainties about 80 and 40X must be reiterated.

The 80X system is not competitive if it must be produced at prices that apply to higher reductions. But if 80X fiche should in fact be available at approximately one-half the high-reduction charges,

		Sets Manufactured						
40X: 38,881 fiche		25	100	300	750	1,000	2,000	3,000
High fixed cost:	$833,843	41,130	16,114	10,555	8,888	8,610	8,193	8,054
Low fixed cost:	$507,843	28,090	12,854	9,469	8,453	8,284	8,030	7,945
Fiche (20¢)	$7,776							
80X: 12,736 fiche								
High fixed cost:	$3,901,200	167,510	50,474	24,466	16,664	15,263	13,413	12,762
Low fixed cost:	$1,664,700	78,050	28,109	17,011	13,682	13,127	12,294	12,017
Fiche (90¢)	11,462							
*High fixed cost:	$2,309,400	98,107	28,825	13,429	8,810	8,040	6,886	6,501
*Low fixed cost:	$1,028,000	46,851	16,011	9,158	7,102	6,759	6,245	6,074
*Fiche (45¢)	$5,731							
115X: 6,085 fiche								
High fixed cost:	$2,390,575	101,099	29,382	13,445	8,663	7,867	6,671	6,273
Low fixed cost:	$999,700	45,476	15,473	8,808	6,809	6,476	5,976	5,809
Fiche (90¢)	$5,476							
150X: 3,375 fiche								
High fixed cost:	$1,898,450	78,976	22,022	9,366	5,569	4,936	3,987	3,671
Low fixed cost:	$728,700	32,186	10,325	5,467	4,010	3,767	3,402	3,281
Fiche (90¢)	$3,038							

Key Values in the table = Fixed cost ÷ number of sets + cost of one set of fiche

High fixed cost: Higher mfr. price for masters + higher filming estimate (both from Fig. 3).

Low fixed cost: Lower mfr. price for masters + lower filming estimate.

*Alternative estimate for 80X with masters and fiche at 50% of first estimates, no change in filming estimate.

TABLE IV. MANUFACTURERS' PRICE FOR ONE SET OF FICHE

then the low-estimate price for 3,000 sets drops from $36 million to $18.2 million. In connection with 40X, it was earlier pointed out that the number of fiche involved at this reduction would convert a misjudgment about unit price into a major overall effect. If 40X fiche were to cost $0.15 instead of the estimated $0.20, the manufacturing price for 3,000 sets would drop from $23.8 million to $18 million. This second value is shown in Figure 3 by a dotted line. Such changes would mean that three of the reduction ratios under consideration in this study--40, 80, and 115X--would find themselves in close price competition. Were this situation to develop, it is likely that competitive bidding would be required to resolve the price question.

System factors other than the price of fiche will likely weigh in the final decision, especially at the library level, where differences in system price attributable to reduction ratio may be as low as one or two thousand dollars. The price of readers is one such system factor--one that in the state of the art as of this writing militates against the higher reductions. Another factor is the number of titles on a fiche. Given the parameters set out for this study, this number changes as follows:

Reduction	Titles per Fiche
40X	.5
80X	1.6
115X	3.3
150X	6.0

The predominant opinion of the library community appears to favor a fiche with no more than one title, for this would preserve the traditional bibliographic procedures and services built around the assumption that one title = one physical unit.

Furthermore, the one-title concept invites a look ahead at the model to be described in the next section, which is focused on the publication of single titles in fiche. A fiche at 150X yields a low per-title cost in the calculations to this point because it has been permitted to carry up to eight titles. The placing of several titles on a fiche may not be feasible, except in terms of a collection to be published as a package. If one thinks of publishing a single book (let it be a book of 326 pages, the average in the sample mentioned earlier), then the manufacturer's price of a copy at 150X will be $0.90, plus a share of the master costs allocated according to the number of copies manufactured; while the price of a copy at 40X will be $0.40 (two fiche), plus a share of the master costs. If it appears that total production, over time, will involve a mixture of single-title fiche and multi-title fiche, then the price advantage must be decided in terms of the predicted mix. As Figure 4 shows, if upward of 25-30% of total production takes the form of single-title fiche, then the advantage in manufacturing price shifts from 150 to 40X. The 80X fiche remains

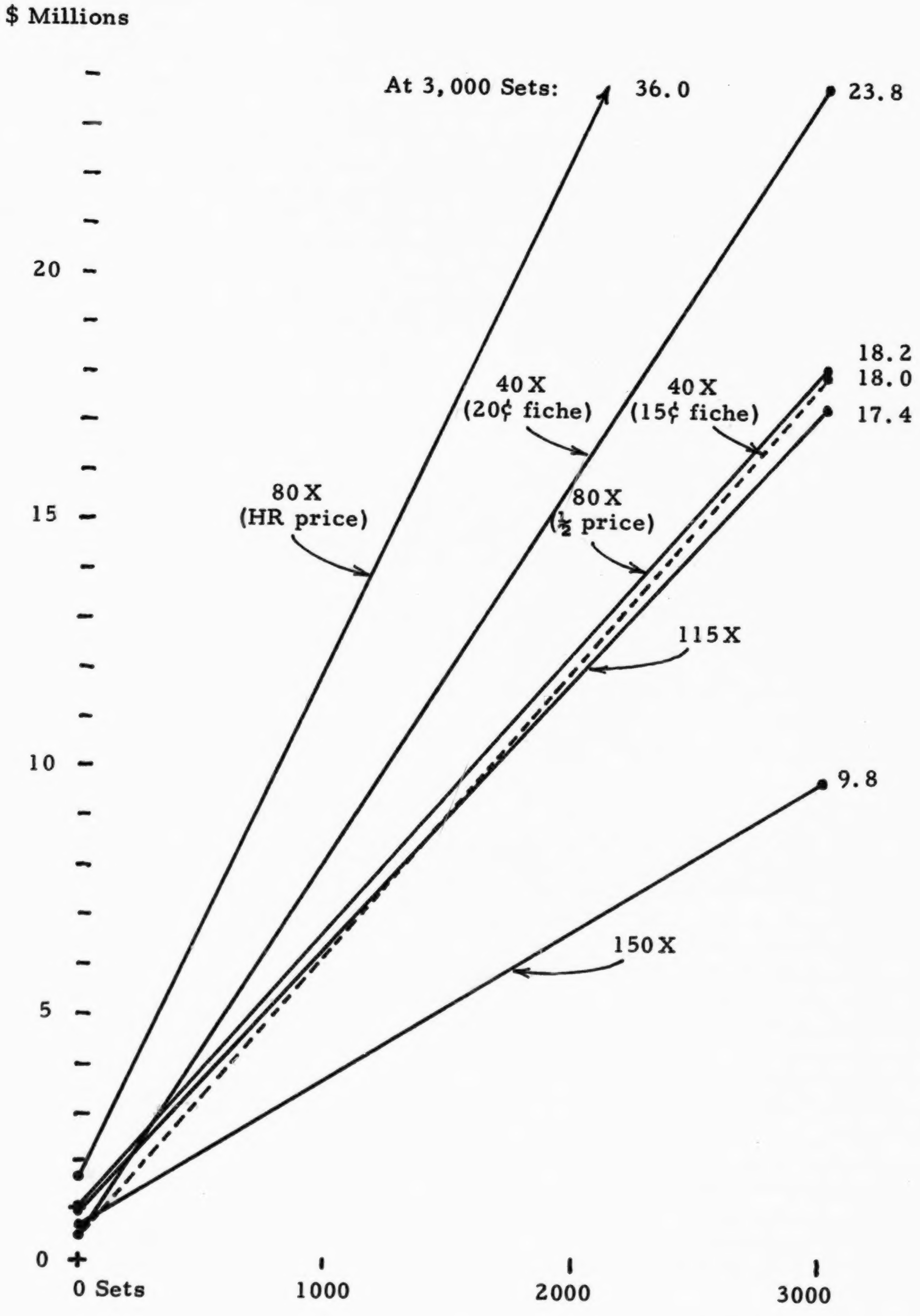
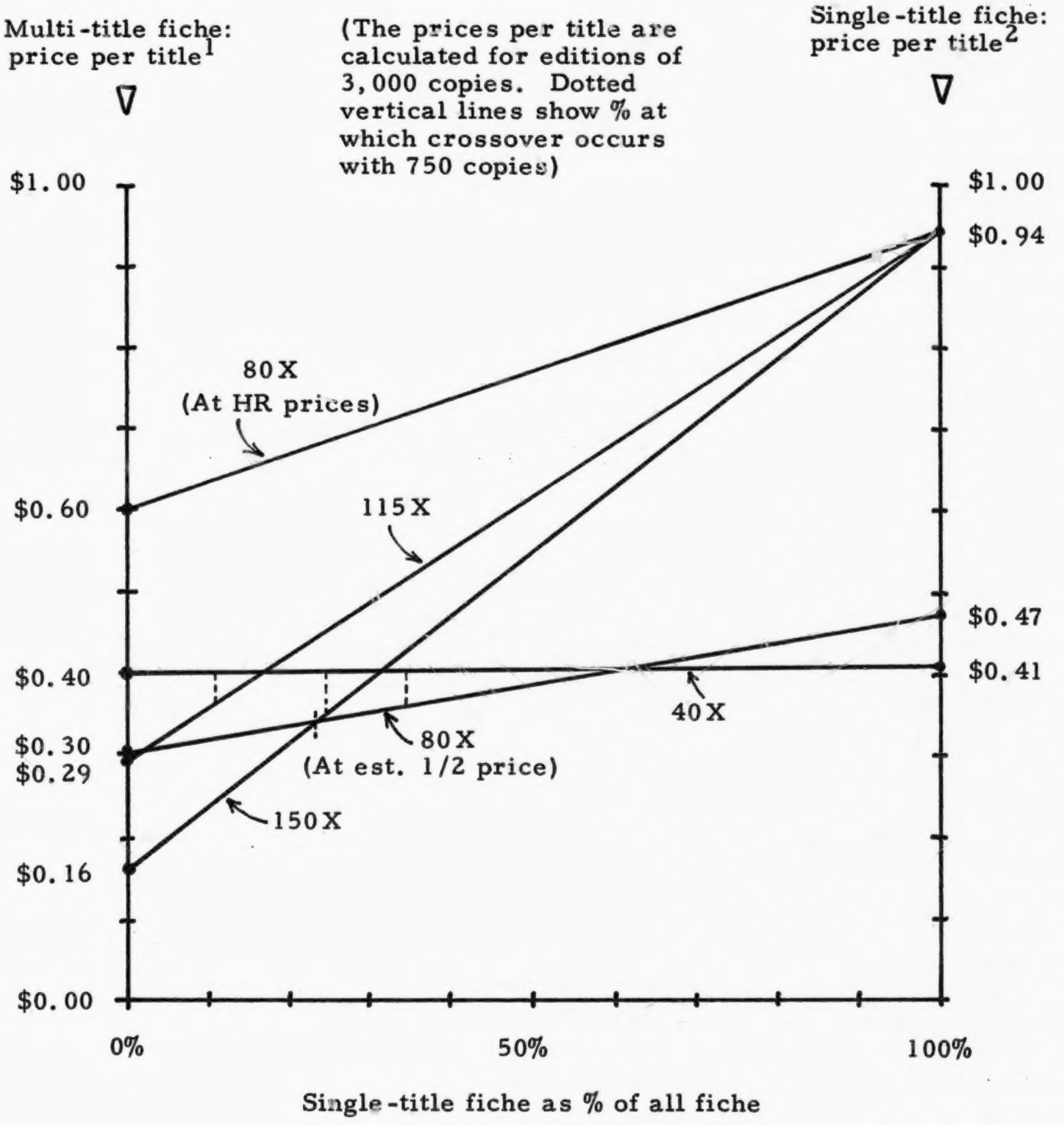


FIGURE 3. TOTAL MANUFACTURING PRICE



[1] Using prices per set from Table IV (low estimates, 3,000 copies) divided by 20,000 titles.

[2] Using unit prices from Table III (the lower price in each case). Assume 326 images filmed. Assume two masters and two fiche at 40X; one each at the other reductions. Then:

$$\text{price per title} = \frac{\text{master + filming}}{3,000} + \text{fiche}$$

FIGURE 4. AVERAGE MANUFACTURING PRICE PER TITLE FOR DIFFERENT MIXES OF SINGLE-TITLE AND MULTI-TITLE FICHE

an economic question. If it must be manufactured at high-reduction prices, then it is out of competition. But if the half-price estimate described earlier should approximate reality, then 80X demands consideration as a medium for the mixed production of single titles and large collections.

Addendum

The cost/price estimates used throughout this Appendix were based on information available to the authors as of July 1, 1969. As this material goes to press, new information has come to hand concerning the pricing for 60, 70, and 80X microfiche for a large collection. While this pricing is still proprietary, we can state that it is somewhat lower than the half-price estimates used above for 80X, and that the prices have been quoted against rigorous quality specifications. We believe that these specifications shortly will be available for publication.

It should be pointed out that this does not clearly illuminate the cost/price competition between various reduction ratios, for large-collection prices relating to other ratios have not been obtained from manufacturers.

New data available on readers indicate that the pricing of mid-range readers may be closer to 40X than to higher reductions. A number of manufacturers have analyzed the costs of supplying high-quality lap readers with a screen size of 6-x-9-in. and a blowback of 70X and tentatively have arrived at suggested selling prices of $100-$125 per unit, assuming a large demand, and of approximately $250 per unit for a table reader at 85X with a 10-x-14-in. screen.

THE SINGLE-TITLE MODEL

The Publishing Subsystem

For a setting for this model, it is appropriate to sketch certain of the costs, prices, and functions that are observable in the publishing industry and the book trade. Let a single book be used for illustration: a book with a list price of \$9.00[1] that sells to a library for \$7.20, after a 20% discount. Let it also be assumed that the initial printing was 5,000-6,000 copies. The return from this one sale will be distributed something like this:[2]

\$1.50	Manufacturing cost (typesetting, printing, binding)
\$0.90	Author's royalty (10% of list; may be scaled upward on longer runs)
\$2.10	Editorial costs, overhead, publisher's profit on the initial run
\$0.90	Publisher's distribution cost (marketing, warehousing, shipping)
\$1.80	Dealer's discount (ordinarily 40% of list; in this example the library discount takes half)
\$7.20	

As Figure 4 indicated earlier, high-reduction microfiche makes possible a lower per-title manufacturing cost than the \$1.50 shown above. But how important is the manufacturing price? Book prices (\$9.00 in the example at hand) are set in a manner that is largely independent of such out-of-pocket costs as those for typesetting, printing, and binding. The publisher's judgment about the relationship of price to potential sales is the key element in setting that price. He calls upon his experience with similar books, and he asks (for example): "How many copies can I expect to sell at $7.00? How many at $12.00?" He seeks to maximize his profit. Often he guesses wrong. In the publishing industry, best sellers and income from subsidiary rights offset the losses from many judgments about the price/market ratio for a given title. But given the pricing methods that exist, a major change in the cost to the publisher for manufacturing the book will work only a small change, or none at all, in the list price to the buyer.

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[1] Steckler, Phyllis B. (ed.), The Bowker Annual, 1968, 103, shows \$7.99 as the average price for new books (trade and technical) in 1967; if children's books are excluded, the average rises to \$8.83. Institutions of higher education, because of their need for technical publications and retrospective materials seem to experience higher prices.

[2] The values used here are composites from four sources: Coqui (pseudonym), "Selecting the Retail Price," Publisher's Weekly, April 1, 1968, 15-17; Lacy, Dan M., "The Economics of Publishing,"Book Publishing," Book Production Magazine, April 1963, 58-60, and May 1963, 62-64; Quain, Edwin A., "What it Costs to Make a Book: Can the Scholarly Book Pay Its Way?" Book Production Magazine, January 1962, 42-43; Dembofsky, Thomas J., "Why Technical Books Cost What They Do.," Physics Today, March 1966, 65-67.

Will a book in microfiche be sufficiently different to bring about other changes in the price/market structure? Experience with microforms does not illuminate this question. To date, microforms (roll film, fiche, aperture cards, and opaque forms) have been employed chiefly for three purposes: (1) to save space--newspapers and public records are major examples; (2) to preserve information on deteriorating paper; and (3) to provide copies in cases of limited or unpredictable demand, where print-to-order is a desirable policy, made feasible by the low cost of microfilm. Among the examples of this third class are engineering drawings, as are technical and professional papers available through such agencies as the Clearinghouse and ERIC. Doctoral dissertations from University Microfilms, Inc., are also of this category.

A fourth use of microfilm has moved forward in recent years; that is, as a vehicle for publishing large collections of historical materials. Some of these collections, available or announced, number 5,000, 10,000, or 20,000 volumes (or the equivalent in pages) at per-volume prices ranging from $0.75 to $2.00. But these prices do not arise solely from the use of microfilm. They are more properly attributed to the fact that such collections attack a wide array of costs that presently confront both the publisher and the library. For example, a sale represents one transaction instead of 5-, 10-, or 20,000 transactions. This is a major saving for both seller and buyer. Thus the relatively low per-volume price of the large collections can be attributed, at least in part, to the reduced costs of distribution.

Distribution costs are a major item. In the book example of a moment ago, 50% (including the library discount) of the $9.00 list price was earmarked for such costs. A note on paperback publishing may be helpful at this point, not because the paperback necessarily affords an analog to microfiche, but because it raises relevant issues. A part of the price advantage enjoyed by the early paperbacks lay in the fact that distribution costs were minimized. Both advertising and sales effort were omitted; the books were sold through magazine dealers, who placed them on display and permitted them to sell themselves--which they did. A circle is evident: the books were priced for impulse buying; impulse buying in volume made the price profitable.

But as the number of paperbacks grew, the directness of appeal was lost in the welter of covers. The books no longer sell themselves as expeditiously as before, and this is part of the reason why the price is no longer 25 cents.

Trade paperbacks (the "quality" paperbacks sold through book stores, rather than magazine outlets) are priced above the level of impulse buying in a mass market, but still must achieve volume sales to return a profit. One publishing executive has pointed out that the trade paperback publisher is prone to look for college course use before he accepts a book.[1] Thus the two kinds of paperbacks illustrate the two conditions in which American publishing, according to another executive in the industry, achieves effective distribution: either the audience is large or it is specialized and well defined.[2]

Another observation to be made about paperbacks is that they opened a market not reached by hard-cover books. The separateness of the two markets for many titles is sufficiently distinct to permit simultaneous publication in both forms with the expectation that the paperback will not destructively affect the hard-copy sales. Later publication in paperback is perhaps more familiar, and here the reverse applies: with luck, the paperback will reach mass markets that were untouched by the hard-cover edition.

Against this background, what can be said about the cost of distributing a book in microform? It can be envisioned that shipping, handling, and warehousing costs will drop because of the reduced bulk and weight. But it is not equally easy to imagine that marketing costs will drop; in fact, until the medium is well established, a great deal of added marketing push may be required. This brings the issue down to a definition of the potential market.

Will fiche open new markets? Or will this new medium simply cut into the sales of hard-cover and paperback? If a new market develops, and if present pricing methods hold, then the price of fiche to the user will very likely be set at a level that represents a maximum exploitation of the market. This price may be low. But not necessarily. If the fiche are bought because they turn out to be convenient, or because they save space, or because they offer some other fit-to-application, then the price can be raised without damage to sales, and one is not amiss to suggest that this is what will happen. The very real possibility that fiche will simply cut into the potential sales to libraries of the other media diminishes the prospect of a major price break.

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[1] Johnson, Pike, "The Trade Paperback," in Grannis, Chandler B. (ed.), What Happens in Book Publishing, New York: Columbia University Press, 1967, 126-127.

[2] Lacy, Dan M., "The Economics of Publishing," Book Production Magazine, May 1963, 64.

The questions here cannot be resolved in terms of the publishing subsystem alone. A look at the library subsystem is called for and is offered next.

The Library Subsystem

Like publishing costs, certain library costs can be sketched in broad terms. In practice, if one seeks to compare two libraries or to assess the efficiency of one, broad terms will not do, for different libraries are directed to different goals, employ different procedures, face different costs of living, and group their activities in different departmental and budgetary arrays. But a picture of the cost domains that bear on the application of microfiche will be useful and may be put forth in terms of the cost of handling a single book:

$7.20	Purchase price, from preceding section
$7.00	Book selection, ordering, receiving, cataloging, marking, shelving
$6.00	Circulation: 15 loans over an assumed system life of 50 years
$9.00	Housing the book for 50 years
$1.40	Rebinding, loss, vandalism, book retirement
$30.60	

For the interested reader, the next four paragraphs sketch the sources used for these costs.

A number of sources point to $7.00 for the second item. William H. Kurth, for example, has reported on six studies of acquisition and cataloging costs.[1] Four were multiple-library studies. One examined a single library. One was based on a conjectural model.

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[1] Kurth, William H., "Costs of Processing," an unpublished preliminary draft of Chapter 6, in Turner, Edward (principal investigator), *A Study of the Implications of Modern Technology for Small College Libraries*, in preparation for the U.S. Office of Education (Project No. 7-0910, Grant No. OEG-1-7-070910-3706).

Their findings ranged from $3.76 per title to $7.77, with a cluster in the range of $4.33 to $4.50. Only one, the conjectural model at $7.77, included selection costs. A study of processing costs for science monographs at Columbia University arrived at a total of $10.26.[1] A study of the undergraduate library at the University of Michigan led to estimates ranging from $10-14.[2] The two university studies include selection. The use above of $7.00 seems within the range suggested by these studies.

For circulation (each loan), a study at Purdue University arrived at a figure of $0.43 (personnel costs only).[3] A survey at an unnamed university library produced an estimate of $0.58.[4] At the University of Michigan, an analysis of the budget for circulation activities in the central library set the variable cost "of providing the book and all the byproduct services" at $0.60-80.[5] The same author estimates the cost per circulation at the Michigan student library as $0.20-40. The $6.00 used above assumes 15 loans at $0.40 each, over a system life for the book of 50 years.

The $9.00 for storage again assumes a 50-year system life for the book; it employs the annual storage rate of $0.135 per year calculated by Fussler and Simon in 1961, adjusted to $0.18 for inflation.[6]

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[1] Fasana, Paul J. and Fall, James E., "Processing Costs for Science Monographs in the Columbia University Libraries," Library Resources and Technical Services, Winter 1967, 97-114.

[2] Meier, Richard L., Social Change in Communications-Oriented Institutions, University of Michigan, Report No. 10, Ann Arbor, March 1961, 20.

[3] Lister, Winston C., Least Cost Decision Rules for the Selection of Library Materials for Compact Storage, Purdue University, Lafayette, Indiana, January 1967, (Clearinghouse: PB 174 441), 173.

[4] Bryant, Edward C., and others, Library Cost Models: Owning Versus Borrowing Serial Publications, a study by Westat Research, Inc., for the Center for Research Libraries, Chicago, Illinois, August 1968, 9.

[5] Meier, op. cit., 33.

[6] Fussler, Herman H. and Simon, Julian L., Patterns in the Use of Books in Large Research Libraries, The University of Chicago Library, 1961, 260. Inflation factors from Simon, Kenneth, Projections of Educational Statistics to 1977-78, U.S. Department of Health, Education and Welfare, Washington, D.C., 1969, 133.

The last item is a remainder of other costs for handling books. It is an arbitrary, rounded 10% of the $14.20 used in the above example to suggest the cost to a library for placing a book on its shelves ($7.20 price, plus $7.00 for selection and processing). The $1.40 includes $0.10 for book binding,[1] $1.00 for lost books,[2] and $0.17 for the clerical costs of book retirement or transfer to compact storage when the library runs out of space.[3] No specific estimates are offered for the costs of vandalism, of searching for lost books, of the handling costs associated with book binding (the $0.10 is bindery charge only), nor of the costs for professional review of book retirement lists. On the whole, the $1.40 is conservative, as are the other costs that precede it.

Potential Impact of Fiche. Many of a library's costs and procedures for selecting, ordering, and receiving books would not be affected by a change in medium. And yet some differences seem predictable. For example, where an approval system is part of a library's machinery for selection, fiche can be expected to reduce certain of the costs that attend the shipping, handling, and returning of books sent out on approval by a dealer. Inspection procedures for books purchased on fiche may become more burdensome than for conventional books, at least until publication in microform achieves a better reputation for quality control than now exists. Allen Veaner has published quality guidelines that should be useful to both publishers and librarians.[1] Over the long term, one should also expect an increased rate of publication in microform to improve the librarian's chances for success when he seeks to buy an out-of-print title. At present, this process imposes a cost for maintaining records and encumbering funds, followed by a percentage of failure that requires records to be cleared and funds freed. Gains in this regard are a contribution of microforms in general, not merely of fiche.

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[1] Quatman, Gerald L., The Cost of Providing Library Services to Groups in the Purdue University Community--1961, Purdue University, Lafayette, Indiana, June 1962, 31-32. This study estimates that books use 5% of the annual budget for binding. The 5% equals 1.4% of the budget shown for new books. Thus for the sample above: .014 x $7.20 = $0.10.

[2] Assuming that the annual loss rate in volumes equals 7% of the number of volumes added. In the example above, the cost of adding a volume is $14.20; thus: $14.20 x .07 = $0.99. The .07 is a compromise. With the help of volumes-added data from the ALA's Library Statistics (op cit.), ratios of losses to additions have been derived from three articles: Roberts, Matt, "Guards, Turnstiles, Electronic Devices, and the Illusion of Security," College & Research Libraries, July 1968, 259-275 (ratio at one university: .185); "Climbing Book Losses Sink Honor System," Library Journal, November 1, 1968, 4086 (ratio at one college: .043); "9,000 Volumes Stolen from Stacks of Five Washington, D.C., University Libraries," Library Journal, October 1, 1966, 4609 (ratio for the five: .073).

[3] Fussler and Simon, op. cit., 244. This estimate was published in 1961 and assumes an hourly wage rate of $1.50.

Cataloging and Filing. Need cataloging change? It appears that book conventions will serve for fiche. A public catalog arranged by classification will be needed to serve browsers. (Very likely this will not be the shelflist for fiche, for fiche do not encourage shelving or filing by classification.) Provision will have to be made on the fiche for marking and adding accession numbers, or, where fiche are precataloged, for introducing modifications to suit local practices. The use of paper jackets would facilitate marking (while rendering useless the machine-readable coding area that was provided in the fiche format assumed for this study).

Since fiche themselves will not permit browsing, they need not be filed by classification. It seems likely that the accession number will serve as the shelf or file code. Thus a new fiche will not be inserted somewhere in the middle of the existing file, but will always be added at the end. Many persons have worried about maintaining file integrity with fiche. Misfiling is one part of this concern. It should be noted that a file drawer of fiche, given that none will be added in the middle, can have a pattern marked across the top of the fiche (perhaps a diagonal line, from the left front corner of the drawer to the right rear) that will show at a glance whether any are out of place. It does not appear that the costs of file maintenance will exceed the cost of stack maintenance, though doubtless fiche will be misfiled, just as books are misshelved. It is assumed here that access to the files will be limited to library personnel and that file custody will be combined with circulation control. While this arrangement implies an increased need for persons to staff the control desk, it also represents a reduction in the need for shelvers or pages, especially in those libraries that maintain closed stacks.

Circulation. A number of persons interviewed in the course of this study expressed interest in the concept of dissemination fiche--that is, of duplicate fiche made at the library from masters and either given to the patron or sold to him at a price approximating the cost of the duplicate. At conventional reductions of 20-24X, this cost would be in the neighborhood of $0.15. It is assumed that contact printing would be employed and that the duplicate would be made on low-cost diazo film. But at higher reductions, problems develop. The library master will require lamination to protect the images, and this will prohibit contact printing. The duplicate, too, at 80X and higher will require lamination. Moreover, the operation itself, at higher reductions, requires skill and clean, well-controlled working conditions. These circumstances are reflected in the prices quoted earlier in this report for fiche at higher reductions--prices of $0.80 and $1.00 per fiche, with some possibility that 80X fiche might be priced lower. Peter R. Scott has voiced the idea that high-reduction storage might be made to yield low-reduction dissemination copies through the use of optical printers.[1] This would combine the advantages of compaction offered by high reductions with the economical edge, in costs of processing and readers, that belongs to low reductions.

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[1] "The Crisis in Micropublication," Choice, June 1968, 448-453; July 1968, 739-744.

But on the whole, the technical questions that arise from the contemplation of a dissemination system are not as difficult as the copyright questions. On-the-spot duplication of whole text will require payment of royalties to authors and publishers. With Congress and the Copyright Office at work on major revisions of copyright law, the time is inopportune for conjectures about fees for dissemination systems or about the procedures for collecting fees. For this model it is assumed that fiche circulate under the same controls that now apply to books, and while some procedural differences are evident (for instance, the fiche is taken from file by the control clerk, not the patron) the same costs are assumed.

One other aspect of circulation invites conjecture; it hinges on the future role of the library in the learning-teaching process. An increasing emphasis on independent study is becoming evident in higher education, even in the first years. This trend promises a new importance for the library and its materials. But whether the library becomes the physical setting for learning is another matter. The impulse to break the confines of the traditional classroom or lecture hall may shatter the campus walls as well. In such a circumstance the physical form of the library might then become that of a central repository with many outposts (storefronts ?) containing catalogs, indexes, and other reference aids; instructional aids and devices directed to the use of the library; and an order service promising half-day response from the repository. The materials-handling costs in such an arrangement would be reduced by the use of fiche.

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[1] In an interview, October 1968. The same concept has been advanced by Jack Ver Hulst, "An Approach to the Development of A Large Volume Microform Dissemination Library System," NMA Journal, Spring 1969, 111-112.

Space and Miscellaneous Costs. While the cost factors discussed to this point are sufficiently uncertain to discourage estimates, two other factors appear otherwise: one is the decrease in cost resulting from the lessened space requirements of fiche and from reductions in such miscellaneous expenditures as those for binding, loss, vandalism, and retirement programs; the other is a new cost arising from the need for readers.

File space for storing fiche up to the equivalent of 20,000 volumes shall be treated here as a negligible cost. The space demands for storage are such that they can be incorporated in areas presently devoted to other functions, such as the circulation desk. Table V provides estimates of the space needs for 20,000 volumes, assuming the fiche are stored in 18-in. trays (occupied to 15 in.) that are placed side by side on a counter or desk top for easy access. It would no doubt be preferable to halve or quarter some of the larger dimensions by making the trays into drawers, stacked two- or four-high in a cabinet. Two space estimates are given, one for unjacketed fiche, the other for fiche in paper envelopes. For all but 150X, fewer envelopes than fiche are required because some titles (of 40X, most titles) occupy more than one fiche.

One advantage of the single-title concept is that it assumes a slow build-up of the fiche collection. This allows the library to acquire readers one at a time, in response to known demands. Presumably the demand for library readers would be tempered by increasing levels of personal ownership of readers on the part of faculty and students.

A mid-range price for a high-reduction reader in the current market can be estimated at $460, or $92 yearly, over a five-year period. This includes the cost of a maintenance contract. For a 40X reader, let a price of $120 be assumed, or $24 annually, again, with an allowance for maintenance. The core collection model to be described in the next section allocates 40 sq.ft. for carrel space incorporating a reader. Fussler and Simon, in 1961,[1] suggested $2.025 per square foot as a representative annual cost for stack space; constant-dollar indices projected to 1969-70 revise this amount upward to $2.70.[2] Thus space for the carrel costs $108 yearly. It should be noted that a square foot of such space would be occupied by 15 books, the number used by Fussler and Simon, at a cost of $0.18 per book.

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[1] Patterns in the Use of Books in Large Research Libraries, op. cit., 260.

[2] Simon, Kenneth, Projections of Educational Statistics to 1977-78, op. cit., 133.

		Inches[1]	Trays[2]	Space
40X	38,881 fiche	389	26	36" x 85"
	20,000 jackets	400		
	Jacketed fiche	789	53	36" x 156"
80X	12,736 fiche	127	9	18" x 59"
	12,101 jackets	242		
	Jacketed fiche	369	25	36" x 85"
115X	6,085 fiche	61	4	18" x 26"
	5,951 jackets	119		
	Jacketed fiche	180	12	36" x 39"
150X	3,375 fiche	34	3	18" x 20"
	3,375 jackets	68		
	Jacketed fiche	102	8	18" x 52"

[1] Assuming laminated fiche .01 in. thick. Laminated fiche, depending on the film used and the kind of lamination, may range in thickness from .006 in. to .015 in. Jackets are assumed to be .02 in. thick allowing for folds and overlaps.

[2] Trays are assumed to measure 18 x 6.5 in. overall, occupied to 15 in.

TABLE V. SPACE REQUIREMENT FOR STORING FICHE

When a fiche is purchased instead of a book, this $0.18 is saved. Also saved is the array of book-related miscellaneous costs, earlier estimated at $1.40 for 50 years, or $0.028 yearly. The total: $0.208. With these values in mind, one can estimate the number of titles in fiche that would offset (at $0.208 per fiche) the costs of a reader and its associated space:

High reduction (100-150X)

Space	$108	
Reader	$ 92	
	$200	÷ $2.208 = 962 titles in fiche

Low reduction (40X)

Space	$108	
Reader	$ 24	
	$132	÷ $0.208 = 635 titles in fiche

It should be pointed out that the space costs used here are relative costs. Whatever the true costs for a given library, the cost-per-book and the cost-per-carrel would be in the same ratio, given that they are calculated for the same part of the building and that 15 books per square foot of stack area adequately represents the library's shelf loading.

The core-collection model to be described in the next section provides evidence that a ratio of 13 readers (including two reader-printers) to 20,000 titles in fiche will prove suitable for some number of institutions. This is about 1,540 titles per reader. If a single reader can in fact "support" that many titles, then fiche would appear to represent an economy for the library. The cost difference can be expressed in terms of 1,540 titles as follows:

Books:	System cost:	$30.60* x 1,540 =		$47,124
Fiche:	Purchase:	$ 7.20*		
	Process:	$ 7.00*		
	Circulate:	$ 6.00*		
		$20.20 x 1,540 =	$31,108	
	High-reduction reader and its associated space:	$200 x 50 yr. =	$10,000	$41,108
	Low-reduction reader and its associated space:	$123 x 50 yr. =	$ 6,600	$37.708

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*From the opening paragraphs of this section on the library subsystem.

THE CORE COLLECTION MODEL

This chapter examines the major effects on library patrons, library personnel and procedures, and library suppliers of making available a core collection published in microfiche. Note that the difference between paper and fiche is not the only issue; a more significant difference is in the contrast of item-by-item acquisition with the one-time acquisition of a large package.

We have defined a "core collection" as a collection of 20,000 monographs covering all fields of knowledge and capable of supporting a college teaching program that depends heavily upon the library. It will include some scholarly works for the use of faculty and exceptional students. The model is concerned only with the initial development of the collection; it does not provide for the continuing acquisition of new titles.

The model provides for four reduction ratios--40, 80, 115, and 150--and examines system effects and costs at each ratio. In addition, costs are amortized over a number of users ranging from 25 to 3,000. No attempt at an actual market forecast has been made.

The Collection Concept

What are the virtues of acquiring 20,000 titles at a time? First, there is the reduction in the number of individual transactions and procedures in the library, beginning with the ordering of titles, through acquisition, mechanical processing, cataloging, and shelving. On the publishing and book trade side, there is a reduction in marketing and distribution operations, both within the system and in interactions with library customers.

Central organization of the collection makes this decrease in operations possible. Arrangements already exist whereby libraries may acquire a number of titles at one time or under one contract from middlemen/suppliers who function as a liaison between publishers and libraries. This reduces the costs of selection and purchasing. In addition, a few academic libraries have formed into groups to provide for centralized selection, purchasing, and technical processing. Each library must still file its own catalog cards and shelve its own books.

As an extension of the concept of joint selection, acquisition, and processing, an integrated, packaged collection of 20,000 titles appears potentially useful to many libraries. The heart of the collection assumed for this model is a set of laminated fiche. The fiche specifications and quantities required at each reduction ratio were discussed earlier in the section entitled "The Fiche: Format and Prices." The collection will be accompanied by a catalog in both book and fiche forms. (A card catalog is also envisioned as an optional item at additional cost. The price of a set of cards and the costs of interfiling in the public catalog are likely to be prohibitive for many institutions; hence, the book and fiche catalogs are designed to accommodate all user needs.)

In current practice, two methods of book catalog production are used. They differ primarily in the page composition process. In the first method, the bibliographical information is placed on magnetic tape. The tape is then used to operate computerized typesetting equipment. A platemaking negative is the end product. In the second method, standard catalog cards are arranged on a page in three columns, seven to a column. The page is photographed and a film negative is produced. From this point, the two methods become one. The negative is used to make offset plates and the pages are run off and bound into volumes.

Since typesetting requires re-keyboarding of copy that, in this case, already exists, libraries have tended toward the low-cost photographic method. It is possible that, in coming years, with Library of Congress cards on tape, computerized typesetting will become more economical. However, this study employs the photographic method for cost estimating purposes.

The catalog will permit entry by author, title, subject, and classification. We have estimated that a collection of 20,000 titles will need approximately 120,000 cards to satisfy catalog requirements. With 21 cards per page (three columns, seven to a column), the catalog will be about 5,700 pages long. This assumes no overlapping, or shingling, of cards. Another assumption is that the catalog will be bound in six volumes. This may prove to be disadvantageous from a user standpoint. The volumes in this hypothetical catalog will measure 10 x 14 in., the trim size which is common to book catalogs produced by the photographic method. The estimated prices allow for printing on heavy-duty, chemically treated paper designed especially for library use and for a sturdy, library-type binding. Three sets of the book catalog will be provided with each set of fiche, plus one fiche catalog.

The Copyright Issue

Obtaining rights to reproduce titles is a critical factor in the publication of a packaged core collection. Estimating this task is difficult because of the current controversy over Constitutional and statutory copyright law as it now exists. The controversy has stemmed from advances in reprography technology over the last 20 years which have resulted in a proliferation of convenient and inexpensive copying devices. On one side stand the creators and publishers, who view the casual, low-cost copying made possible by these machines as a violation of their rights and a misinterpretation of the concept of "fair use" (a concept which, fundamentally, provides for limited reproduction of copyrighted materials for educational and research purposes). On the other side stand the equipment manufacturers and other concerned individuals who are interested in advancing the cause of research and the state of the art of information storage and retrieval (and, in the case of the manufacturers, selling their products).

Out of these differences has come the effort, still underway, to reexamine various aspects of copyright and to amend the statutes as necessary. For all media the issue is one of property and a fair return therefrom. How does one define "fair return" when the market is unknown, as is the case with fiche at the reductions considered in this study? Reprint royalties in the publishing industry are at levels dictated, at least in part, by the nature of the subsidiary market. Two cases are evident. In one, the original publisher feels that he has exhausted the market to which his business is directed and he grants reprint rights to another publisher who wishes to undertake the risks of exploring the demand for a new edition. In this case, the subsidiary market is seen as small or uncertain, a price of $10.00 or more may be proposed for the reprint, and the original publisher accepts a royalty of 10-15% in the face of the conservative market estimate but relatively high price. In the second case, he extends reprint rights to a mass-market publisher and accepts royalties as low as 4% on a low selling price against the prospect of volume sales.

The core-collection book in fiche fits neither circumstance. Because the books in the collection will tend to be of recent date, many of them will still be active in the original publisher's market. Nor can it be assumed that the academic libraries of the nation constitute a high-volume market. Will 4% serve where the price is low and the volume small? The publisher who sees in each sale of a fiche a book left unsold on his shelves may seek a return that will offset this lost sale. A publishing executive (while pointing out that actual royalties would have to be determined by negotiation) offered his personal view that the minimum acceptable royalty would be 25% of the original publisher's list price, running up to 33.3%. [1] But this would be a burden unacceptable to the microform publisher. Perhaps a more tenable solution would be the development within the industry of formulas that consider the current volumes of sale, the date of the original copyright, and the projected number of sales in the new format. In absolute terms, it would appear that a reprint in fiche could not support a royalty greater than $1.00 and remain viable in the marketplace.

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[1] Lacy, Dan M., in correspondence with the authors. Mr. Lacy is a senior vice-president of McGraw-Hill Book Company and former managing director of the American Book Publishers Council. The views expressed in his letter are his own and not necessarily those of McGraw-Hill.

It would be useful to estimate the highest amount a fiche publisher could expect to pay for rights. If, as was stated earlier, the fiche core collection will be similar in content and scope to the collection listed in Books for College Libraries,[1] one can infer that the percentage of titles with active copyrights will be about the same for both. A random sample of titles in the ALA list showed that roughly 80% were published recently enough for their copyright to be active (no attempt was made to estimate the renewal of older copyrights). A figure of 80% translates to about 16,000 titles (in the fiche collection), which would require royalty payments--thus using the upper ($1.00) estimate of acceptable royalties, $16,000 for every collection sold.

We have not built this cost into our projections of incremental costs because of the uncertainties we have expressed about copyright legislation and about acceptable levels of payment. We have, however, listed possible copyright costs in a separate section of our projections to provide some insight into the magnitude of copyright payments, as related to other project costs.

Functions and Tasks

In the development of a core collection in fiche, five categories of tasks must be considered. They include editorial tasks, copyright investigation, bibliographic development, production, and distribution. The estimated time for development of the collection, from initial planning and hiring of staff to delivery of the first collection, is assumed to be approximately two years.

Each of the five task categories is discussed briefly below:

Editorial Tasks. The principal tasks (in order, over time) include the appointment of an advisory board, and hiring an editor-in-chief and an editorial staff to conduct the project. Policies, goals, procedures will be established. Subject-area specialists will be selected to assist in the title nomination and selection process. Title nominations will be obtained from the editors, advisory board, subject-area specialists and source lists, and will be placed on magnetic tape. A computer program will allocate titles to each specialist for review and evaluation. Preferred editions and translations will be identified in the process. The list of selected titles will be pruned in an additional review and evaluation by the subject-area specialists. Final selection of the title list will be approved by the editors and advisory board. After selection, sources for copies of the titles will be located and arrangements will be made to procure the copies for filming. For books in print, an economically advantageous filming arrangement would result if publishers were to provide copies that could be cut apart. This would doubtless be a provision of any royalty agreements. It is assumed that a large portion of the titles not obtained in this fashion can be filmed, intact, at the Library of Congress; the remaining titles will require arrangements with other libraries. A computer program will be developed to determine the optimum arrangement of titles on the fiche, seeking to minimize the use of film while preserving established bibliographic groupings. This program will be integrated later with a computer program prepared by the production staff to determine camera settings and the sequence of photography.

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[1] Voigt, Melvin J. and Treyz, Joseph H. (ed.), Books for College Libraries, Chicago: American Library Association, 1967, 1,056 pp.

Copyright Investigation. A committee will be appointed to investigate the copyright issue, and a copyright director will be hired. With a supporting staff, the director will determine the copyright status of titles and negotiate permissions for reproduction. Earlier, it was pointed out that at least 80% (16,000 titles) of the collection is likely to be in active copyright. This gives some idea of the magnitude of the copyright director's task. Even if the percentage of active copyrights were as low as 50%, the number of titles affected would still be 10,000.

Bibliographic Development. A chief bibliographer and a staff of assistant bibliographers and catalogers will be hired. Goals, policies, and procedures which will govern the creation of bibliographic tools will be established. Wherever possible, LC cards will be obtained. Modifications and additions will be made to the LC cards, and new cards will be made for titles without LC identification. Computer files will be kept for all bibliographic data and a program will be developed to make and correct entries and to print out catalog cards. Internal fiche indexes will be prepared as camera-ready copy, according to production specifications. These indexes will be delivered to the microfilmers and the catalog cards will be delivered to the book catalog publishers for processing and production.

Production. It is essential that the production process be well planned and coordinated. A production coordinator will be hired and will work with the fiche and equipment manufacturers and the book catalog publisher to design and implement a system permitting an orderly flow of documents throughout the production process. This may be done with the aid of existing computer programs adapted to the unique requirements of this project. A programmer will establish a master control list once the titles have been selected. Under the supervision of the production coordinator, the fiche manufacturer will examine and calibrate each volume according to size, number of pages, contrast, type fonts, and kinds of illustrations. Document specifications will be submitted to a programmer, who will prepare a program to determine the camera setting suitable for each document. This program will be integrated with that prepared by the editorial staff for arrangement of documents on fiche. A final program will yield a printout of camera schedules governing the sequence of document photography and the camera settings, as well as the final arrangement of the documents on the fiche.

Material will be filmed and inspected for quality; disqualified pages will be rephotographed. We have assumed a two-step process. Test prints will be run off from the master; prints will be inspected for quality and disqualified masters will be reshot. Dissemination prints will be produced to meet the distribution requirements.

Distribution. The package concept will require a sizeable public relations effort: first, because it involves change; second, because of the librarian's past experience with microforms, which has been burdened with poor materials and machines and with a diversity of incompatible systems; and finally, because it imposes upon the librarian's prerogatives of selecting and cataloging titles for his library.

This last is a formidable objection to overcome--yet, the answer to it may lie within the core collection concept itself. William Kurth of Washington University has proposed such an answer: "A list of titles chosen by a panel of experts provides not only more evenly balanced but more economical selection. Very few institutions can bring expertise to bear in all subject areas. The chances are extremely high that a panel of experts... can do this better. Economically, the college stands to gain because it can deploy its 'selection forces' to more purposeful tasks...."[1]

Thus, distribution efforts will consist of publicity, customer seminars, training programs for library personnel and patrons, and programs to help colleges develop funding sources to meet the cost of the collection.

Scheduling and Staffing

The length of time required to develop the packaged core collection is assumed to be two years. Distribution activities and production coordination (at a decreased level of effort) will continue for at least another year, and beyond that for as long as demand warrants. Table VI shows staffing requirements over a three-year period and Table VII shows staff salaries.

Mechanical Reader and Space Requirements

The implementation of a collection in fiche requires the installation of mechanical readers. There has been little research to date in the area of user reading patterns inside the library, particularly as

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[1] Private correspondence.

	1971				1972				1973			
Editorial												
Director of Library Project	1	1	1	1	1	1	1	1				
Executive Editor	1	1	1	1	1	1	1	1				
Assistant Editors	1	2	2	2	2	2	1	1				
Librarians	1	2	3	4	4	3	2	2				
Editorial Research Assistants	2	3	3	3	3	2	1	1				
Computer Programmers	1	2	2	2	2	1	1	1				
Keyboarders	1	6	4	2	1	1						
Clerk Typists	2	2	3	3	3	2	2	2				
Copyright												
Copyright Director	1	1	1	1	1*	1*	1*	1*				
Bibliographic												
Chief Bibliographer	1	1	1	1	1	1	1	1				
Bibliographers	1	3	3	3	3	3	2	1				
Catalogers	2	8	12	15	15	8	2	2				
Computer Programmers	1	1	2	2	2	2	1	1				
Keyboarders	1	1	1	2	2	2	2	1				
Clerk Typists	2	2	3	3	3	3	2	2				
Administrative												
Controller	1	1	1	1	1	1	1	1	1	1	1	1
Office Manager	1	1	1	1	1	1	1	1				
Secretaries	6	6	6	6	5	5	5	5	1	1	1	1
Library Placement												
Director	1	1	1	1	1	1	1	1	1	1	1	1
Publicity Assistant	1	1	1	1	1	1	1	1	1	1	1	1
Customer Trainers								6	6	6	6	6
Production												
Production Coordinator	1	1	1	1	1	1	1	1	1*	1*	1*	1*
Computer Programmer		1	1	1	1	1	1	1				

TABLE VI. UMF CORE LIBRARY STAFFING

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*Half time

Job Classification	Salary
Director	$30,000
Executive Editor	20,000
Assistant Editor	10,000
Librarian	9,000
Copyright Director	20,000
Editorial Research Assistant	7,000
Production Coordinator	17,000
Chief Bibliographer	17,000
Bibliographer	9,000
Cataloger	8,000
Computer Programmer	14,000
Keyboard	5,000
Controller	15,000
Office Manager	9,000
Library Placement Director	17,000
Publicity Assistant	8,000
Secretary	6,000
Clerk-Typist	5,000
Customer Trainer	12,000

TABLE VII. STAFF SALARIES

they relate to microform usage. How shall an estimate be made of the number of machines required for a core collection in a medium untried in the academic library?

A hypothetical college library possessing 20,000 books has been assumed as a model. The purchase of a core collection of 20,000 titles in fiche would double the library's holdings. It is also assumed that the model library serves as a student body of 600.

One approach to estimating reader requirements for a core collection is to examine student reading habits. If these habits can be characterized in terms of books, then conclusions about them may be applied to a fiche system. This approach builds upon the findings of the Denver Research Institute, where students demonstrated that reading speed and comprehension were the same for both books and fiche. This was true for all reduction ratios tested.

An investigation of student study habits, conducted by John Condon,[1] provides a clue to reader requirements. In his survey of five junior colleges, Condon found that the full-time transfer student ("a student enrolled for twelve or more units of work in an academic program with transfer credits to a four year institution") spent approximately 21 hours a week studying. Condon also determined that two of these hours were spent reading material from the library collection. Since our model assumes, first, that the library contains equal amounts of books and fiche and, second, that these media are used equally, it can be assumed that each student will spend one hour per week reading library fiche. Again, referring to the model, if there are 600 students using the library, fiche will be used 600 hours a week. How many mechanical readers are needed to satisfy this demand?

Let it be assumed that the campus library is open 14 hours a day, six days a week. If students using the reading equipment come to the library on a random basis, seven fiche readers will satisfy the demand:

$$\frac{\text{600 hours/week of fiche reader demand}}{\text{84 hours/week of library access}} =$$

7 fiche readers needed when library is open.

However, students do not go to the library on a random basis. There are peak periods and slow periods of student use. In addition, the above projection does not take into account faculty and other nonstudent reading demands. To accommodate these additional demands, it is assumed here that 50% more fiche readers will be needed--thus, a total of 11 readers.

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[1] Study Habits and Perceptions of Desirable Study Space by California Community College Students, a doctoral dissertation, Stanford University, School of Education, 1966, 280 pp.

Hard-copy reprint needs will require reader-printer facilities. Many academic libraries are able to handle their present hard-copy demands with one reader-printer. However, an hourly average of seven patrons reading fiche is high relative to most current library situations and will create a steady demand for copying facilities. Two reader-printers would be more reasonable under these conditions. Queuing during peak periods will be alleviated and should one reader malfunction, the other will be available.

The assumptions and the equation[1] used in this argument can be employed to plot minimum reader requirements for a sample of libraries, as shown in Figure 5.[2] The testimony of Figure 5 and the conclusions in the preceding paragraphs must be adjusted in cases where student patterns of library use differ from those reported by Condon, where the library hours differ from the 14-hour schedule described above, where experience demonstrates that peak loads call for less than or more than 50% more readers, and where the collection of materials on fiche incurs usage not characteristic of the library's collection as a whole. One can intuit that a core collection, by definition, will enjoy heavier usage than a collection in a given subject area, especially an esoteric one. No attempt to predict such effects has been made.

Space requirements for mechanical readers and reader-printers must also be estimated. Recent literature recommends 40 sq.ft. per

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[1] The equation for minimum reader need, assuming level demand throughout the day:

$$\text{need} = \frac{\text{fiche vols.}}{\text{total vols.}} \times \text{enrollment} \times 2 \div 84$$

where 2 is the time in hours that a student spends with library materials each week, and 84 is the number of hours that the library is open weekly. Since the holdings shown in Figure 5 are actuals, not adjusted upward by 20,000 volumes in fiche, the reader-need curves derived from this equation have been adjusted downward by 20,000 volumes.

[2] The library data in Figure 5 represent a 5% sample of the 1,891 institutions listed in the American Library Association, Library Statistics of Colleges and Universities, 1965-66 Institutional Data, op. cit., 10-84.

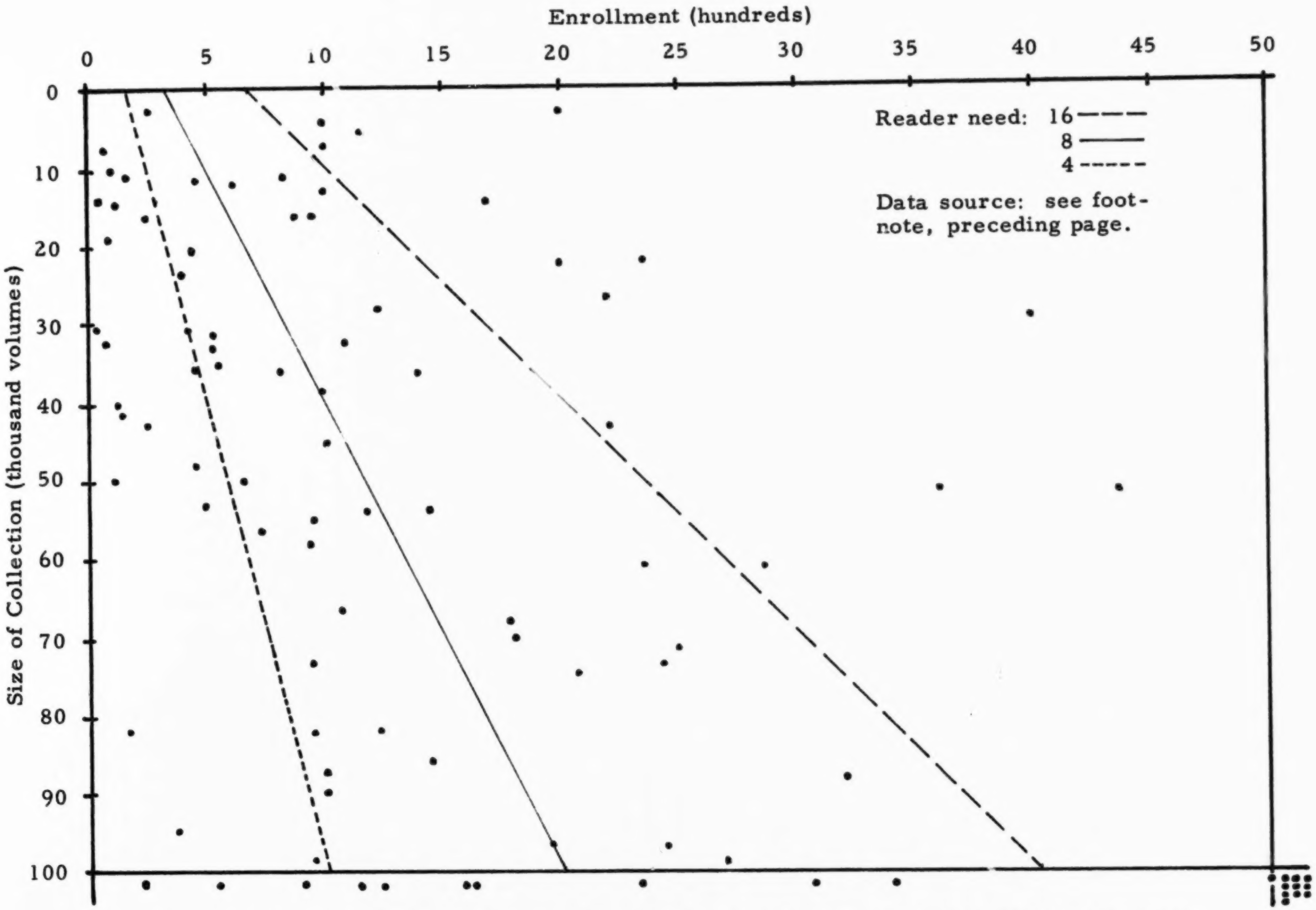

FIGURE 5. MINIMUM READER NEEDS FOR A SAMPLE OF ACADEMIC LIBRARIES

reading station.[1] Using this figure, the total floor space required for 13 reading stations will be 520 sq. ft. The annual cost of such space would be $1,404 in accord with the estimates developed earlier at the end of the section on the single-title model. The cost of a high-reduction reader (100-150X) is estimated to average about $460; the cost of a low-reduction reader (40X) is estimated to average about $120. These figures include the cost of service and maintenance for five years. Reader-printers vary widely in cost, depending on specifications and reduction ratio. The top appears to be about $1,500, the low about $300.

Cautions about the estimates offered in this section on readers cannot be too strongly expressed. One reviewer of these paragraphs voiced the feeling that the Condon report of student time spent with library materials (two hours weekly) was far too low for four-year colleges or universities, especially the more demanding ones. A major change in this dimension would greatly affect the system-life costs estimated at the end of this chapter. On the other hand, some offsetting factors can be noted. For one, the reader replacement schedules used in the cost estimates to follow call for all readers to be replaced every five years. It is doubtful if that rate would be observed in fact. Another point concerns the private ownership (or lease) of readers by faculty and students. If fiche are to become a major form of publication, the possession of readers cannot be limited to the library. The low-cost, personal reader must become commonplace on the campus and be put to a variety of instructional uses. This will lower the requirement on the library to provide readers and will spread reader costs over a greater number of learning/teaching programs, not just those that require or encourage the use of library fiche. Finally, one's judgment of all these matters must be tempered by the accelerating rate of change in reader design and by the probability that a greatly increased market for readers would introduce new economies of scale into their manufacture.

Economic Analysis

The costs of producing a core collection in fiche may be divided into fixed and incremental costs. The fixed costs are a function of the decision to publish a collection of a given size, containing given materials; except for fiche masters, the fixed costs are independent of the reduction ratio used. The incremental costs are a function of the number of sets published. As the number of sets goes up, incremental costs become a higher and higher proportion of total project costs.

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[1] Weber, D. C., "Design for a Microtext Reading-Room," UNESCO Bulletin, Vol. 29, July 1968, 303-309. Also, see Metcalf, K. D., Planning Academic and Research Library Buildings, New York: McGraw-Hill, 1965, 112.

Incremental Costs. There are two types of incremental costs. The first is the cost of laminated fiche copies for each package. The number of fiche required for a package and their cost varies with reduction ratio. This information is shown in Table IV, above. Incremental costs of fiche for each hypothetical market are shown in Table VIII.

The second type of incremental expense comprises the costs of paper, binding, and press running time for the book catalog. The price of paper was estimated to be $2.00 per volume ($12.00 per set); binding costs were estimated at $4.50 per volume ($27.00 per set). This totals $39.00 per set for paper and binding alone. Since it is assumed that the book catalog will be subcontracted, the $39.00 figure was increased to $43.00 to permit a 10% profit. Press speed for a 35 x 45 offset, one-color, perfecting press (a press that prints on both sides of a sheet at one time) was estimated at 9,000 pages per hour (16 pages at a time), at an hourly rate of $60.00. For a book catalog of 5,700 pages, press running time would cost $38.00. Total incremental cost for one book catalog is $81.00. The sum of these incremental costs for book catalog production (assuming three copies per package) are shown in Table VIII. Total incremental costs are also given in Table VIII.

Fixed Costs. Table IX shows fixed costs in three categories: development expenses, administration and overhead, and distribution expenses. All salaries were determined from the staffing schedules and salary schedule shown in Tables VI and VII. Employee benefits and taxes (Items A. 10, B. 2, and C. 3) were estimated at 25% of direct salaries. Overhead (Item B. 3) was estimated at 30% of the sum of all direct salaries and excludes capital investment.

Item A. 1, book-catalog presswork, includes composition, page preparation and platemaking, press setup, and plate changes during the press run. Composition was estimated at $4.00 per page; page setup and platemaking were estimated at $1.40 per page. Press setup and plate changes were estimated at $60 per hour. If it is assumed that there are 16 pages per press run, that initial press setup takes one hour, and that each of the succeeding plate changes (356 in number) takes 30 minutes, a total of 179 hours of press time will be required. This yields a cost of $10,740 for presswork, $22,840 for composition, and $7,994 for page preparation and platemaking--a total of $41,574.

Items A. 2. a, A. 2. b, A. 2. c, and A. 2. d represent the cost of producing fiche masters at four reduction ratios, respectively. These estimates were taken from the prices shown earlier in Table IV. The high estimates were used in order to give a conservative cost picture.

Item A. 3 is the estimated cost of producing prototype fiche prior to the beginning of production. Item A. 4 is an estimate of the cost of

	Sets Manufactured						
	25	100	300	750	1,000	2,000	3,000
Fiche (40X)	$194,400	$ 777,600	$2,322,800	$5,832,000	$ 7,776,000	$15,552,000	$23,328,000
Fiche (80X)	$286,550	$1,146,200	$3,438,600	$8,596,500	$11,462,000	$22,924,000	$34,386,000
Fiche (115X)	$136,900	$ 547,600	$1,642,800	$4,107,000	$ 5,476,000	$10,952,000	$16,428,000
Fiche (150X)	$ 75,960	$ 303,800	$ 911,400	$2,278,500	$ 3,038,000	$ 6,076,000	$ 9,114,000
Book Catalogs*	$ 6,075	$ 24,300	$ 72,900	$ 182,250	$ 243,000	$ 486,000	$ 729,000
Subtotal (40X)	$200,475	$ 801,900	$2,405,700	$6,014,250	$ 8,019,000	$16,038,000	$24,057,000
Subtotal (80X)	$292,625	$1,170,500	$3,511,500	$8,778,750	$11,705,000	$23,410,000	$35,115,000
Subtotal (115X)	$142,975	$ 571,900	$1,715,700	$4,289,250	$ 5,719,000	$11,438,000	$17,157,000
Subtotal (150X)	$ 82,025	$ 328,100	$ 984,300	$2,460,750	$ 3,281,000	$ 6,562,000	$ 9,843,000

TABLE VIII. TOTAL INCREMENTAL COSTS OF PUBLISHING A CORE-COLLECTION

*Paper, binding, and press running time

		1971	1972	1973	Three-Year Total
A.	**Development Expenses**				
1.	Book Catalog Presswork	---	41,574	---	41,574
2a.	Fiche Development (40 X)*	833,843	---	---	833,843
3.	Prototype Fiche	10,000	---	---	10,000
4.	Computer Terminal Time	8,000	12,000	---	20,000
5.	Honoraria for Advisors				
	20 @ $2,000/yr. each	40,000	---	---	40,000
	200 @ $300 each	60,000	---	---	60,000
6.	Editorial Salaries	162,500	133,250	---	295,750
7.	Copyright Director	20,000	10,000	---	30,000
8.	Bibliography Salaries	153,250	133,500	---	286,750
9.	Production Salaries	27,500	31,000	8,500	67,000
10.	Employee Benefits and Taxes	90,812	76,937	2,125	169,875
11a.	40 X Subtotal	1,405,905	438,261	10,625	1,854,792
*2b.	Fiche Development (80 X)	3,901,200	---	---	3,901,200
11b.	80 X Subtotal	4,473,262	438,261	10,625	4,922,148
*2c.	Fiche Development (115 X)	2,390,575	---	---	2,390,575
11c.	115 X Subtotal	2,962,637	438,261	10,625	3,411,523
*2d.	Fiche Development (150 X)	1,898,450	---	---	1,898,450
11d.	150 X Subtotal	2,470,512	438,261	10,625	2,919,398
B.	**Administration and Overhead**				
1.	Administration Salaries	60,000	54,000	21,000	135,000
2.	Employee Benefits and Taxes	15,000	13,500	5,250	33,750
3.	Overhead	134,475	121,425	37,950	293,850
4.	Subtotal	209,475	188,925	64,200	462,600
C.	**Distribution Expenses**				
1.	Distribution Salaries	25,000	43,000	97,000	165,000
2.	Employee Benefits and Taxes	6,250	10,750	24,250	41,250
3.	Subtotal	31,250	53,750	121,250	206,250
D.	Totals--Fixed Costs				
1.	40 X	1,646,630	680,936	196,075	2,523,642
2.	80 X	4,713,987	680,936	196,075	5,590,998
3.	115 X	3,203,362	680,936	196,075	4,080,373
4.	150 X	2,711,237	680,936	196,075	3,588,248

TABLE IX. BREAKDOWN OF FIXED COSTS FOR A CORE COLLECTION IN FICHE

computer terminal hours for all programming needs connected with the project. Item A.5 includes the honoraria paid to both advisory board members and subject-area specialists.

Table X shows fixed costs of a core-collection package amortized over each of seven hypothetical production runs. The resulting figures represent a per-unit cost to the publisher. Table XI shows total project costs at the various production quantities. The amounts shown represent the sum of decreasing (amortized) fixed costs and increasing incremental costs. Table XII shows the cost, at various production runs, of placing a packaged core collection in a college library. Note that reprint royalties are not included in these costs. In computing the values shown in Table XII, it has been assumed that the publisher of the core collection is a nonprofit agency.

Table XIV represents the 50-year system-life costs of fiche collections at the four reduction ratios for three hypothetical production runs. The values used to compute these costs are shown in Table XIII. It should be pointed out that a change in the number of mechanical readers needed will work a major change in the predicted system-life costs. On page 25 of this Appendix, the 50-year system-life cost for a single book was estimated at $30.60. When multiplied by 20,000, the system-life costs for a book collection, in terms of the tasks or functions evaluated in this study, total $612,000, more than three times any of the costs shown in Table XV.

Economies of Scale

It should be pointed out that economies of scale have not been investigated in this study. The values used here have been derived from published costs and prices based on a limited manufacturing experience. As of July 1, 1969, two high-reduction systems (both at 150X) were in commercial operation.[1] One employs 8 masters and the other 38, but the first is updated entirely every two months, while the second is revised at the rate of five masters every six weeks. In terms of annual production, the two are similar:

	System A	System B
Pages filmed (yr.)	120,000	90,000
Masters produced (yr.)	48	45
Copies produced (yr.)	192,000	144,000
System users	5,000	3,200

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[1] Both are manufactured by National Cash Register Company. Both are systems for maintaining parts catalogs, one for an automobile manufacturer, the other for a large, retail merchandising firm.

	Sets Manufactured						
	25	100	300	750	1,000	2,000	3,000
Administration and Overhead	$ 18,504	$ 4,626	$ 1,542	$ 617	$ 463	$ 231	$ 154
Distribution	$ 8,250	$ 2,063	$ 687	$ 275	$ 206	$ 103	$ 69
Development (40X)	$ 74,192	$18,548	$ 6,183	$2,473	$1,855	$ 927	$ 618
Development (80X)	$196,886	$49,221	$16,407	$6,563	$4,922	$2,461	$1,641
Development (115X)	$136,461	$34,115	$11,372	$4,549	$3,412	$1,706	$1,137
Development (150X)	$116,776	$29,194	$ 9,731	$3,893	$2,919	$1,460	$ 973
Subtotal (40X)	$100,946	$25,236	$ 8,412	$3,365	$2,524	$1,262	$ 841
Subtotal (80X)	$223,640	$55,910	$18,738	$7,455	$5,591	$2,796	$1,864
Subtotal (115X)	$163,215	$40,804	$13,601	$5,441	$4,080	$2,040	$1,360
Subtotal (150X)	$143,530	$35,882	$11,961	$4,784	$3,588	$1,794	$1,196

TABLE X. FIXED COSTS FOR PUBLISHING ONE CORE-COLLECTION PACKAGE

	Sets Manufactured						
	25	100	300	750	1,000	2,000	3,000
40X	$2,724,000	$3,326,000	$4,929,000	$ 8,538,000	$10,543,000	$18,562,000	$26,581,000
80X	$5,884,000	$6,761,000	$9,102,000	$14,370,000	$17,296,000	$29,001,000	$40,706,000
115X	$4,223,000	$4,652,000	$5,796,000	$ 8,370,000	$ 9,799,000	$15,518,000	$21,237,000
150X	$3,670,000	$4,916,000	$4,573,000	$ 6,049,000	$ 6,869,000	$10,150,000	$13,431,000

TABLE XI. COST OF A CORE-COLLECTION PROJECT TO A PUBLISHER

Sets Distributed*

	25	100	300	750	1,000	2,000	3,000
40X	$108,960	$33,260	$16,430	$11,384	$10,543	$ 9,281	$ 8,860
80X	$235,360	$67,610	$30,340	$19,160	$17,296	$14,500	$13,569
115X	$168,920	$46,520	$19,320	$11,160	$ 9,799	$ 7,209	$ 7,079
150X	$146,800	$39,160	$15,263	$ 8,065	$ 6,869	$ 5,075	$ 4,477

*Note that the prices shown do not include an estimated $16,000 per package for reprint royalties.

TABLE XII. NO-PROFIT PRICE OF A CORE COLLECTION TO THE COLLEGE LIBRARY

Royalties	$16,000
Reader space (40 sq.ft. per unit, 13 units, $2.70 per sq.ft. per year, 50 years):	$70,200
	$86,200
High-reduction readers ($460 per unit, 11 units, replaced 10 times in 50 years):	$50,600
High-reduction reader-printers ($800 per unit, 2 units, replaced 10 times in 50 years):	$16,000
	$66,600
Low-reduction readers ($120 per unit, 11 units, replaced 10 times in 50 years):	$13,200
Low-reduction reader-printers ($400 per unit, 2 units, replaced 10 times in 50 years):	$ 8,000
	$23,200

TABLE XIII. VALUES USED FOR SYSTEM-LIFE COSTS IN TABLE XIV

	300 Units	750 Units	2,000 Units
40X			
Fiche and catalogs	$16,430	$11,384	$ 9,281
Royalties and space	86,200	86,200	86,200
Low-reduction readers	23,200	23,200	23,200
	$125,830	$120,784	$118,681
80X (At HR estimates)			
Fiche and catalogs	$30,340	$19,160	$14,500
Royalties and space	86,200	86,200	86,200
High-reduction readers	66,600	66,600	66,600
	$183,140	$171,960	$167,300
115X			
Fiche and catalogs	$19,320	$11,160	$ 7,209
Royalties and space	86,200	86,200	86,200
High-reduction readers	66,600	66,600	66,600
	$172,120	$163,960	$160,009
150X			
Fiche and catalogs	$15,263	$ 8,065	$ 5,075
Royalties and space	86,200	86,200	86,200
High-reduction readers	66,600	66,600	66,600
	$168,063	$160,865	$157,875

TABLE XIV. FIFTY-YEAR SYSTEM-LIFE COSTS TO A LIBRARY

In System A, not all users receive copies of all masters; we have estimated the average dissemination to be 4,000 copies. In terms of the number of fiche copies made from a given master, these systems provide experience that compares with the 3,000-unit production runs used as the upper value in the study model. Thus some relevance attaches to the fact that the manufacturer has published a price of $1.00 per duplicate fiche, "regardless of quantity."

On the other hand, the study model provides for a total production (assuming 3,000 copies of each master) that ranges from 116.6 million fiche at 40X down to 10.1 million at 150X. This differs conspicuously from the annual production of 336,000 fiche for the two existing systems, taken together. Even at 1,000 copies, the production of 150X fiche for the core collection would differ from that of the existing systems by more than an order of magnitude. Production economies and lower prices to the publisher presumably would result from such differences, arising out of increased experience, out of the more efficient use of personnel and facilities, and out of volume purchases of materials.

This same manufacturer quotes prices for fiche masters with no adjustments for quantity. But here again, the difference--fewer than 100 masters (annually) in one case against 3,375 to 38,881, in the other--suggests that economies of scale not established in this study would be operative.

The microfiche-study staff at Denver Research Institute have asked for a comment on the fiscal implications of a collection of 50,000 titles, instead of 20,000. A critical question is whether the increased production would call for a longer schedule or a larger capital investment. The first case would lower the capital costs per unit; the second would not, and the manufacturer would be doubly concerned to ask about other applications that would use his facilities, once the project ended. Unfortunately, a packaged core collection, with reasonably up-to-date materials and a fully integrated book catalog, calls for speed in its production.

Are these offsetting aspects of a collection of 50,000 titles? If the microfiche system requires that new materials (film stock, for instance) be developed, multiplying purchase quantities by 2.5 might shift the price from that of a special order to that of a standard item. An increased demand for readers, in connection with a larger body of filmed materials, could introduce economies in reader manufacture. Otherwise, unlike the initial jump to 20,000 titles, this additional step does not readily suggest significant economies of scale in the manufacturing processes (filming, making masters, producing fiche, and printing and binding catalogs). That is to say, the costs of those processes might well increase by a factor approaching 2.5, barring an extension of schedules.

On the publishing side, the mechanisms set up to handle 20,000 titles would not need to expand 2.5 times to handle 50,000. Table XV suggests some of the upward adjustments that might be required in the costs estimated earlier (Table IX) for 20,000 titles. With those costs adjusted as shown, and with other manufacturing costs uniformly increased by a factor of 2.5, the per-title cost of items in the collection would change, as shown by the examples offered in Table XVI.

Development Expense	No change	Times 1.5	Times 2.5
Presswork			$103,935
Prototype fiche	$ 10,000		
Computer terminal			50,000
Honoraria		$150,000	
Editorial salaries		443,625	
Copyright director		45,000	
Bibliography salaries			716,875
Production		100,500	
Benefits and taxes on salaries above		184,781	179,219
	$ 10,000	$923,906	$ 1,050,029
Administration & Overhead		$693,900	
Distribution Expense	$ 206,250		
		TOTAL	$2,884.085

TABLE XV. FIXED PUBLICATION COSTS FOR 50,000 TITLES

	Number of Copies		
Collection Size	300	1,000	3,000
40X			
20,000 titles	$0.82	$0.53	$0.44
50,000 titles	$0.67	$0.48	$0.43
150X			
20,000 titles	$0.76	$0.34	$0.22
50,000 titles	$0.61	$0.30	$0.21

TABLE XVI. SOME COMPARATIVE PER-TITLE COSTS FOR COLLECTIONS OF 20,000 AND 50,000 TITLES

SUMMARY AND CONCLUSIONS

This study has investigated the potential economic impact upon the academic library of high-density microfiche from the viewpoint of two models. The findings can be briefly summarized:

The Single-Title Model

First, a general observation or two. Books in microfiche at the reduction ratios considered in this study offer a small but clear economic advantage to the library over conventional books. But it is by no means clear that incentives exist for the publishing industry to employ microfiche as a medium for general, commercial publication--that is, the publication of single titles in quantities matching those of books in hard cover or paperback. (The publication of large, integrated packages represents a different case, as will be discussed shortly.)

This may change, or the statement about incentives may misrepresent the facts. Potential markets, offering incentives, may exist outside the library. The presence on a number of campuses of large, packaged collections in high-density microfiche (now being announced for sale) may encourage the publication of single titles in the same medium. The economic advantages of microfiche, however small, may encourage some number of libraries to request titles in that form. While perhaps not suited to all library purposes, fiche would appear acceptable for titles aimed at a limited audience. If the library community were to examine its procedures, goals, and services in depth, additional advantages of microfiche might appear, and this would add to the market potential of the medium.

The basic conclusions are these:

1. Only in space-saving did the single-title model of this study show a clear advantage over materials in book form. On this one dimension, the model indicated a system-cost advantage, fiche over books, of 13-20%. While procedural differences in handling fiche, as distinct from books, can be discerned in selecting, processing, and circulating library materials, the cost differences are subtle and not easy to establish.

2. The model revealed no clear incentives for the commercial publication of single titles in fiche.

3. If the pricing practices that now prevail in the publishing industry are applied to books in fiche, then the different manufacturing costs represented by different reduction ratios will not be a factor in defining a system for general, volume publication in microform. The manufacturer's price for putting a single, 326-page book on fiche (and no more than one) will range from $1.25 (high-reduction, 750 copies)

down to $0.41 (40X, 3,000 copies). Manufacturing costs in this range are swallowed by other pricing factors.

4. For the library, on the other hand, different reductions produce different reader costs. The difference between high-reduction readers and 40X readers (given the price assumptions used in this model) appears to represent a difference in potential system-life costs of 8-10%.

The Core-Collection Model

The acquisition of a core collection in fiche appears to have potential advantages for many academic libraries. The attractions of such a package are diminished or enhanced by a number of factors: the reduction ratio and format of the fiche; the organization of the collection: the size of the market; the availability of low-cost, reliable mechanical readers and reader-printers; the degree of willingness on the part of library personnel and patrons to embrace a new medium; and the motivation of a publisher to tackle a project as complex and massive as the publication of a core collection in a new medium. As these factors vary, so does the feasibility of the collection.

We can infer that some configurations of these parameters will prove favorable to the acceptance and success of such a venture. Yet at least two crucial issues remain uncertain at this time. The first is the copyright issue. As was noted above, one can only speculate on the nature of future legislation. The second is the task of forming a coalition of publishers who are interested in contributing their materials, and then negotiating an arrangement which is both agreeable and profitable to them.

Assuming that these issues can be resolved in such a way as to encourage the development of a collection in microfiche, let us draw some conclusions from the material presented.

1. As the size of the market increases, fiche costs become an increasingly important investment consideration, particularly at the lower reduction ratios.

2. 80X appears to be the least attractive economically of all the reduction ratios studied, though there are indications that the state of the art is advancing to a point where fiche produced at 80X and other "mid-range" ratios are becoming less expensive.

3. Although total project costs to the publisher and unit price to the library appear to be most attractive at the high reduction ratios, particularly in combination with a large market, more research needs to be done on the problems of retrieval and queuing that may arise from placing several titles on each fiche.

4. Fifty-year system-life costs of collections at every reduction ratio studied are less than one-third the costs (for market sizes of 300, 750, and 2,000) associated with a book collection of equal size. (This assumes nonprofit operation on the part of the fiche publisher.)

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[1] The working bibliography for this appendix (203 items relating to library costs and operations, to the publishing and printing industries and the book trade, and to microform technology) can be obtained on request from: TECHNOMICS, Inc.
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APPENDIX B

STUDENT READING CHARACTERISTICS: COMPARING SKILL-LEVELS DEMONSTRATED ON HARDCOPY AND MICROFORM PRESENTATIONS

INTRODUCTION

The technology which permits 3000 pages of printed material to be reproduced on a 4 × 6-inch film card, initially was explored with respect to its impact upon the needs of colleges and universities, by asking "To what extent are the reading skills of the student preserved when utilizing microform presentations?" The technology suggests that large holdings, requiring small storage space, might be made available at relatively small cost to existing libraries as well as newer educational institutions, if the communication of information is not impaired by use of microimages rather than hardcopy. It was believed that the question posed must be answered first, before considering specific characteristics of ultrafiche, or any other microform, or before consideration of a microform system particularly responsive to education requirements. If the medium were useable in the communication of ideas, and information transfer were not impaired by interposing the machine link into the communications chain, then by examining the needs and capabilities of the undergraduate user, within the limitations imposed by the area of application and the technology itself, a sound basis might be established for the introduction of ultrafiche into the educational field.

The main areas for research initially identified included: (1) development of the economic implications of ultrafiche systems, (2) a determination of the range of library materials (physical characteristics) that could be successfully presented on ultrafiche, (3) an analysis of reader (machine) characteristics in terms of user preference and performance, and (4) the design of educational information systems based on ultrafiche. These areas of research would have impact, however, only if it were demonstrated that machine presentations of educational material could be utilized by the student to an extent consistent with his use of hardcopy materials. The first step, then, was to determine if the medium was appropriate to the intended use; this determination was the objective of the experimentation described here.

THE PROBLEM

In addition to a concern as to the effectiveness or efficiency of communication across the man-machine interface, the question of reduction ratio intrudes. This added consideration stems from the technical implications of high reduction ratios. Present microform systems operate primarily in the range of 18x to 24x while the ultrafiche system (as defined for purposes of this study) ranges from 40x to 150x. The image area on the film card, corresponding to the high reduction interval, ranges from 4 to 70 times smaller than that of the conventional microforms; thus, the possibility of user performance variations as a function of reduction ratio itself had to be studied. In a limiting view, the amount of information that can be retained in the microimage is proportional to the area of the image, film and optical resolution being constant. In the absence of information to the contrary, the performance level of a student was assumed to be dependent on the quality of the presentation; since the quality of the microimage essential to that presentation is dependent on the amount of reduction, reduction ratio was accepted as one of the independent variables in the study.

A review of the literature for significant previous studies relative to evaluating performance using microform presentations was unrewarding. The principal contributions to experience in this area flow from commercial applications which have little in common with an educational application. Specifically, the important differences can be seen in the users themselves, the nature of the information, and the conditions surrounding the use of the information. The nature of the information is a point of critical difference. In the commercial application, the transaction across the man-machine interface is "search" orientated, with data retrival as the usual objective. The educational application emphasizes the communication of the subtle and the abstract through an extended transaction. This dichotomy suggested that descriptive materials, in monographic form, and reflecting two levels of difficulty, would be appropriate for the information base of the study since performance and presentation quality might interact differently in response to the varying demands made on the user by a variation in the difficulty of the reading materials. Thus, material difficulty was accepted as the second independent variable for the study.

The third variable was, of course, the students themselves. Freshmen and sophomore students in the College of Arts and Sciences* were used in the study in order to characterize the largest general population of college students and to minimize the encounters with students having previous microform experience, speed reading training, or specialized knowledge.

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*At the University of Denver

CONSIDERATIONS IN THE EXPERIMENTAL DESIGN

The study was predicated on the following factors:

1. Readers, as received from the manufacturers, were suitable for the study.

2. Materials in an initial format that is considered highly readable (1)*could be supplied to the manufacturers, and fiche could be obtained having reductions of 38x, 100x and 150x, nominally.

3. A parallel study could be executed, using the input documentation in hardcopy form, which would serve as a basis for performance comparisons.

4. Performance could be defined in terms of reading rate and comprehension level for monographs of approximately 600 words each (one page hardcopy; one frame on a fishe; no machine manipulation required).

5. The test materials would be 18 behaviorally differentiated articles: nine articles characterized as "difficult" by a behavioral response of low reading rate, low comprehension; nine articles characterized as "easy" by the behavioral response of high reading rate, high comprehension.

The controlled factors affecting the presentations were:

Fiche	Readers and Environment
type size	screen angle
type face	screen specular reflections
leading	ambient illumination
row spacing	internal illumination
page size (width)	machine noise level and position

Performance response to the two discrete groups of material was expected to evidence one of three patterns which would gain additional dimension when compared with the hardcopy results.

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* See references at end of Appendix.

1. No degeneration of performance response would occur for either the "easy" or "difficult" material; this would be interpreted to indicate that there are no critical points of discontinuity in the reduction function of ultrafiche.

2. Performance responses to both "difficult" and "easy" material would degenerate at some critical point within the reduction function.

3. The performance response to the "difficult" material would degenerate while the "easy" material would give a base rate of response.

MATERIAL SELECTION

The key to the success of the study lay in the identification of suitable monographs. A pilot study was undertaken to obtain information on the range of means and deviations for both reading rate and comprehension level that could be expected for a student when reading short monographic material in hardcopy form. In addition, it was anticipated that the pilot study would comment significantly on the nature of the material, and particularly on whether or not the appropriate number of differentiated articles could be identified by repetition of the pilot procedure. These differentiated articles would then be committed to a format suitable for experimentation.

The specific purposes of the pilot study were (1) to differentiate two discrete ends of a "difficulty" continuum of the material by behavioral response measures, (2) to establish whether or not reading rate and comprehension level for the same article were positively or negatively correlated, and (3) to obtain profiles on each article for central tendency, variability, and correlation coefficients for reading rate and comprehension level. The pilot study proposed to explore the above parameters and proposed that the following relationships would be established, i.e., that certain discernible patterns of interaction would occur predictably:

1. Significant relationships would be found between articles which appeared at the two ends of the difficulty spectrum.

2. The relationships would differentiate two major groups: Low Reading Rate-Low Comprehension, and High Reading Rate-High Comprehension.

In addition to the above, it was necessary to determine the central tendency and variability for subjects over the two discrete groups of articles which evolved from the pilot, and to determine whether or not there were experimental effects such as learning or fatigue over time. These results were needed to establish the optimum number of subjects and number of presentations for each cell of the experimental design.

The subjects were eight students from the University of Denver who had indicated willingness through the University Job Placement Center to participate in this study. The experimental articles (selected from material used in a reading improvement course given by the University) were administered to the respondents in random order. Data were obtained on a total of 40 variables for each subject; these consisted of 20 measures of reading rate and 20 corresponding measures of comprehension level.

The pilot data indicated that the articles represented in this study could be behaviorally differentiated and that some articles from the far ends of the distribution tended to cluster together and were significantly correlated.

Table B-1 is a profile for articles selected from the two discrete ends of the distribution and gives an indication that articles which cluster together in central tendencies to form the two discrete groups are significantly correlated in a positive direction for reading rates, and correlate positively (if not always significantly) for comprehension levels. An analysis of variance of blocks of responses over time evidenced no significant experimental effects although a slight trend toward learning effects was suggested: the lowest reading rate scores tended to appear early and the highest reading rate scores tended to appear within the last eight responses. No experimental effects were found for comprehension levels.

This initial effort revealed the direction for more refined evaluation of articles and indicated that a body of material which was differentially represented by behavioral response could be developed. In addition to the insight gained thru review of the statistics generated, the study indicated that the longer articles were better suited for the study. Most of the differentiated articles were longer than 500 words (5 of 6) while ten articles that negatively correlated had less than 450 words.

Table B-1. Central Tendency and Variability, and Correlation Profiles for Selected Articles (Pilot Study)

Title and Article Number	Reading Rate		Comprehension		Correlations (Article--Read Rate/Comp Level)		
	Mean	Std. Dev.	Mean	Std. Dev.			
Mental Phenomena (3)	182	46	5.75	1.488		6--.86/.83	9--.58/.56
Reasoning (6)	196	49	6.63	1.303	3--/86/.83		9--.79/.51
TPR (9)	196	34	7.875	.991	3--.58/.56	6--.79/.51	
Cinerama (4)	247	50	8.625	.518		13--.71/.42	14--.52/.77
Capitalism (13)	282	40	9.375	.744	4--.71/.42		14--.69/.62
Brains (14)	261	57	8.75	1.165	4--.52/.77	13--.69/.62	

.05 level of significance = .62

.01 level of significance = .79

The material selection process was continued in the manner discussed in the pilot study. In all, some 100 articles were screened and 45 were prepared for student evaluation. Twenty-five articles, having the desired characteristics in terms of student response, were reformated into highly readable, single page presentations (11-point Press Roman Type, 34-pica line width, and 2-points of leading) using the IBM Selectric Composer System. In this manner, high quality originals were created for the microforming process* and identical copies were prepared on low reflectance stock for the final hardcopy evaluations. While only eighteen articles, nine "difficult" and nine "easy," would be used in the study, the extra materials were required for pretesting and possible substitutions since some necessary editing accompanied the reformating process.

The opening paragraphs of two monographs are presented below in order to indicate the variation between the "difficult" and "easy" classes of material. The comprehension questions (10 per monograph) which supported each article tended to probe for factual information in the "easy" class and a mix of the factual plus abstract relationships in the "difficult" class.

Example of "Easy" Material

HOW TO READ NEWSPAPERS

In spite of radio and television, newspapers still give the American public the bulk of daily information, and it is the newspaper which still fundamentally shapes popular opinion in this country. Thus, it seems only reasonable that people ought to know how to read a newspaper if they are to function as intelligent citizens in our democracy. We should be aware of at least two factors: (1) the need for critical reading, and (2) how to get meaning in news reading. Newspapers are not necessarily oracles of immutable truth. Readers need to remember that newspapers give points of view in many cases, which exist in several forms. News presentation is selective. While the newswriter may have access to all the facts, he exercises his own judgment as to what facts are given and how he gives them. Also news can be weighted; the newswriter can build up certain facts and play down others. Such weighting can take various forms. One is to place certain information on the front page and other information on the inside or back page. The use of headlines and bold-face captions, or conversely, small type and buried matter can influence the unwary reader in assessing the importance of the material.

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*The fiche materials were prepared by both the National Cash Register Company and Microform Data Systems,Inc. at nominal reductions of 40x, 115x, and 150x.

Example of "Difficult" Material

THE GUIDING PRINCIPLES OF REASONING

The object of reasoning is to find out, from the consideration of what we already know, something else which we do not know. Consequently, reasoning is good if it be such as to give a true conclusion from true premises, and not otherwise. Thus, the question of vitality is purely one of fact and not of thinking. A being the premises and B being the conclusion, the question is, whether these facts are really so related that if A is, B is. If so, the inference is valid; if not, not. It is not in the least the question whether, when the premises are accepted by the mind, we feel an impulse to accept the conclusion also. It is true that we do generally reason correctly by nature. But that is an accident; the true conclusion would remain true if we had no impulse to accept it; and the false one would remain false, though we could not resist the tendency to believe in it.

We are, doubtless, in the main logical animals, but we are not perfectly so. Most of us, for example, are naturally more sanguine and hopeful than logic would justify.

THE EXPERIMENT

The final identification of the nine "easy" and nine "difficult" articles to be used in the reader study was accomplished by testing a group of seven students on all 25 of the formated monographs. The average responses for the 18 most highly differentiated articles are presented in Table B-2. This test was designed such that these data would serve the added purpose of defining the expected performance levels for students encountering this same material in hardcopy form.

Table B-2. Average Scores of Seven Students
Reading Hardcopy

Class	Reading Rate	Comprehension Level
"Easy"	280 Words/Min.	84%
"Difficult"	240 Words/Min.	66%

A separate group of 12 students participated in the experiment in which 18 articles (9 difficult, 9 easy) were presented on readers having magnifications of 38x, 115x, and 150x; the presentations obtained were physically equivalent to the hardcopy presentations. A random block design was employed in order to have the students encounter 3 difficult and 3 easy articles on each of the three readers. In this manner, each article was presented four times on each of the readers for a total of 216 presentations. The overall design is described as mixed, having two fixed levels (articles and magnification) and one range of levels (students). The results of this experimentation are presented in Table B-3.

Table B-3. Average Scores of Twelve Students Reading Fiche Materials

Class	Reader		Reading Rate (Words/Min.)	Comprehension Level (%)
	38x		281	84
"Easy"	115x		289	82
	150x		270	85
		Average:	280	84
	38x		251	63
"Difficult"	115x		254	66
	150x		253	67
		Average:	253	66

An analysis of variance was performed on the data obtained in each of the tests summarized above. In addition to the confirmation of significant difference between the "difficult" and "easy" articles (a result obtained under the assumption that all articles in a class were equivalent in terms of expected response), the individual differences among the students, in terms of skill-levels demonstrated, was also found significant.* The differences associated with the three readers was not found to be significant (alpha = 0.10), a result consistent with the first pattern of anticipated experimental outcomes: i.e., no critical points in the reduction function of the ultrafiche.

The surprisingly close correspondence between the mean scores obtained in these two tests (1-hardcopy, 2-fiche) provoked a detailed comparison between the two experiments. While it is obvious that no important difference in skill levels can be associated with the fiche or hardcopy, the fact that a different group of students was used in each test complicates the comparison. However, the students were drawn from essentially the same pool, i.e., predominately Freshman and Sophomore Arts and Sciences majors with no special training in reading skills, and this fact alone would tend to make a comparison appropriate. Of greater importance is the fact that less than 10% of the total variance encountered in the respective comprehension determinations was associated with difference between students, while some 30% of the total variance in each experiment was associated with the difference in the difficulty of the articles. This result suggests that comprehension is a stable indicator of group characteristics, and the similarity in the mean comprehension scores between groups (Tables B-2 and B-3) supports this insight. The comparison of reading rate between experiments is less conclusive because in both experiments the difference between students is associated with approximately 50% of the total variance encountered. Thus, it is possible that the group tested on the fiche presentations could have a significantly different set of mean reading-rate scores if they had worked with hardcopy instead of fiche.

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*The significance was beyond the 0.001 level.

This possibility was examined in two ways. First, the question was asked, "If the presentation aspects were ignored, are the grand means obtained in the reading scores for each experiment consistent with the assumption that the same student population formed the two samples that were tested?" This analysis yielded a probability of 0.8 that the samples were from the same population. With this assurance, three students that participated in the fiche experiment were asked to read five of the articles, available in hardcopy, that they had not seen in their original test. The average reading rates so obtained were used to identify three students from the hardcopy test that had approximately the same average score for the same group of articles. The objective was to compare the nominally matched reading rates obtained for the block of five articles with the reading rates obtained for the 18 articles in the respective experiments. This comparison is summarized in Table B-4. This table indicates that students having similar reading rates performed in a consistent manner regardless of whether the monographs were in hardcopy or on fiche, a result that makes the comparison of reading rates between tests most appropriate.

Table B-4. Average Reading Rates for Paired Students
(Words Per Minute)

	Av. of 5 Control	Av. of 18		
Student	(Hardcopy)	Hard-copy	Fiche	Diff.
A	251	290		39
A'	245		287	42
B	269	298		29
B'	271		327	56
C	222	258		36
C'	232		275	43

POST HOC COMMENTS AND CONCLUSIONS

The considerations inherent in the development of this comparison of hardcopy and microform communications media in education are manyfold, and are well summarized in the work of Klare (2). The network of relationships among readability, material difficulty, motivation, comprehension, and intelligence is most complex, but many of the "between" relationships are understood at this time. A point of particular importance to the study is that a strong motivational set is required in the subject if differences in material difficulty are to be reflected in his reading rate or comprehension level. The fact that the study evidenced stable performance differences comments, then, on the stable motivational state of the students that participated.

Subsequent work has indicated that the differences between machines in average reading rates for easy materials is significant, although this could not be proved from this initial study. The fact that such differences are not seen for the "difficult" material, nor could they be ascribed to the readability of a presentation on a particular reader, has suggested that the inherent difficulty of the reading task controls the level of the subject's awareness of other presentation or environmental aspects operative at the man-machine interface.

The experiment described has resulted in several specific insights in addition to those in answer to the question: "Is microform actually a viable medium for educational purposes?" It should be emphasized that this experiment comments on viability, and does not treat the larger questions implicit in maximizing the effectiveness of the man-machine interface.

It is clear that the reading skill levels of the undergraduate college student are preserved when microform presentations are substituted for hardcopy equivalents. Further, there is no important effect associated with reduction ratio in the sense of technical limitations being active at high magnification. While this latter statement might be qualified because of the control maintained on the input materials, it should be understood that formating for readability was the main effect obtained by this control, and the final hardcopy format was, of course, identical with that used in the microform presentations.

Some of the additional insights can be enumerated as follows:

1. Student performance was uniform from the start of the test to the end; no evidence of fatigue effects after working 2 to 2.5 hours were noted.

2. The subtle difference in reading rate, obtained with only the easy material, suggests a link between the task difficulty and the user's awareness of presentation variations among the readers.

The role of a strong motivational set, intentionally developed in each subject tested, through monetary reward, instruction, and awareness of the comprehension questions to be encountered, should be kept in mind when answering the question: "Can a student's skill-levels be maintained on microform presentations?" The motivational set associated with the student's pursuit of his educational objectives is certainly different; his performance must be evaluated in this larger arena before the question "Will skill-levels be comparable using microforms?" can be answered.

REFERENCES

1. Tinker, Miles A., "Bases for Effective Reading," Minneapolis, Minn.: University of Minnesota Press, 1965, pp. 125-150.

2. Klare, George, "The Measurement of Readability," Ames, Iowa: Iowa State University Press, 1963, pp. 12-180.

APPENDIX C

RANDOM GRAIN PATTERN TECHNIQUE: A METHOD FOR ESTIMATING IMAGE QUALITY

INTRODUCTION

The problem of determining image quality in microform presentations is an exceedingly complex one, and could easily be the only subject considered in this report. The reasons for this complexity are apparent when the quality of hardcopy is considered. For hardcopy, quality can be discussed in terms of legibility. Tinker[1] suggests that any typographical arrangement that significantly reduces speed in reading, in comparison with another setup, can be considered less legible. This definition is concerned with the coordination of factors at all levels which affect ease, accuracy, and speed of reading. If a perfect reproduction of a page of hardcopy could be obtained when presented on a reader screen, then the image quality could be discussed in much the same way as hardcopy. A new factor comes to play with the photographic and projection processes inherent in the creation of a microform presentation: it is the loss of some information contained within the original hardcopy with the transfer to microform. The reasons for information loss lie in both the reduction (photographic) process and the magnification (reader) process, with the net effect that information loss increases with reduction ratio. The important concept here is that information loss is a factor which distorts the conventional meaning of legibility. This distortion exists because a substantial loss of information can be tolerated before any effect is noted in the user's reading skills. Thus, image quality must be discussed in terms of both readability and information preservation.[2] For purposes of the following discussion, readability should be understood in a context of reading skills, and information preservation should be understood in a context of character visibility. (See Appendix E, Fatigue Study, for illustrations.)

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[1] Miles A. Tinker, Bases for Effective Reading, Minneapolis, University of Minnesota Press, 1965, p. 124.

[2] "Legibility," as defined, will be reserved for hardcopy references.

THE RANDOM GRAIN PATTERN TECHNIQUE

Since the program deals with the user's response to specific microform presentations and, in addition, is concerned with the utility of high density microforms as a means of presenting educational materials, the need for a methodology to indicate relative image quality was considered urgent. Suffice it to say that such a methodology did not exist. Conversations with Eastman Kodak representatives lead to a suggestion that a technique being explored by Kodak as a control for the quality of microimages might be adapted to this evaluation problem. The technique, described as a random grain pattern step tablet,[3] operates on the principle of variable signal-to-noise ratio. A document to be evaluated is viewed through a transparency which contains noise in the form of random, opaque grains which are organized in steps of increasing size under the restriction that each step has constant unit transmission. This restriction means that the ratio of grain to open space between grains is constant for all steps. The text is read at normal viewing distance through the different grain steps, with the transparency held motionless while determination is made of the step beyond which the text cannot be read; this summarizes the composite physical characteristics of the documentation and results in a control index.

A series of grain patterns were made as a result of this suggestion and the particular pattern chosen is shown in Figure C-1,[4] together with a sample of text that was used in the performance study reported in Appendix B. The basic pattern was obtained by photographing a random pattern screen[5] in successive steps of reduction (15% per step) and controlling both exposure and processing to achieve a unit transmission of approximately 65%. The grain size in Step 1 is one-fifth that of Step 11.

In the evaluation of image quality, readability was operationally defined as the highest step through which the material could be read

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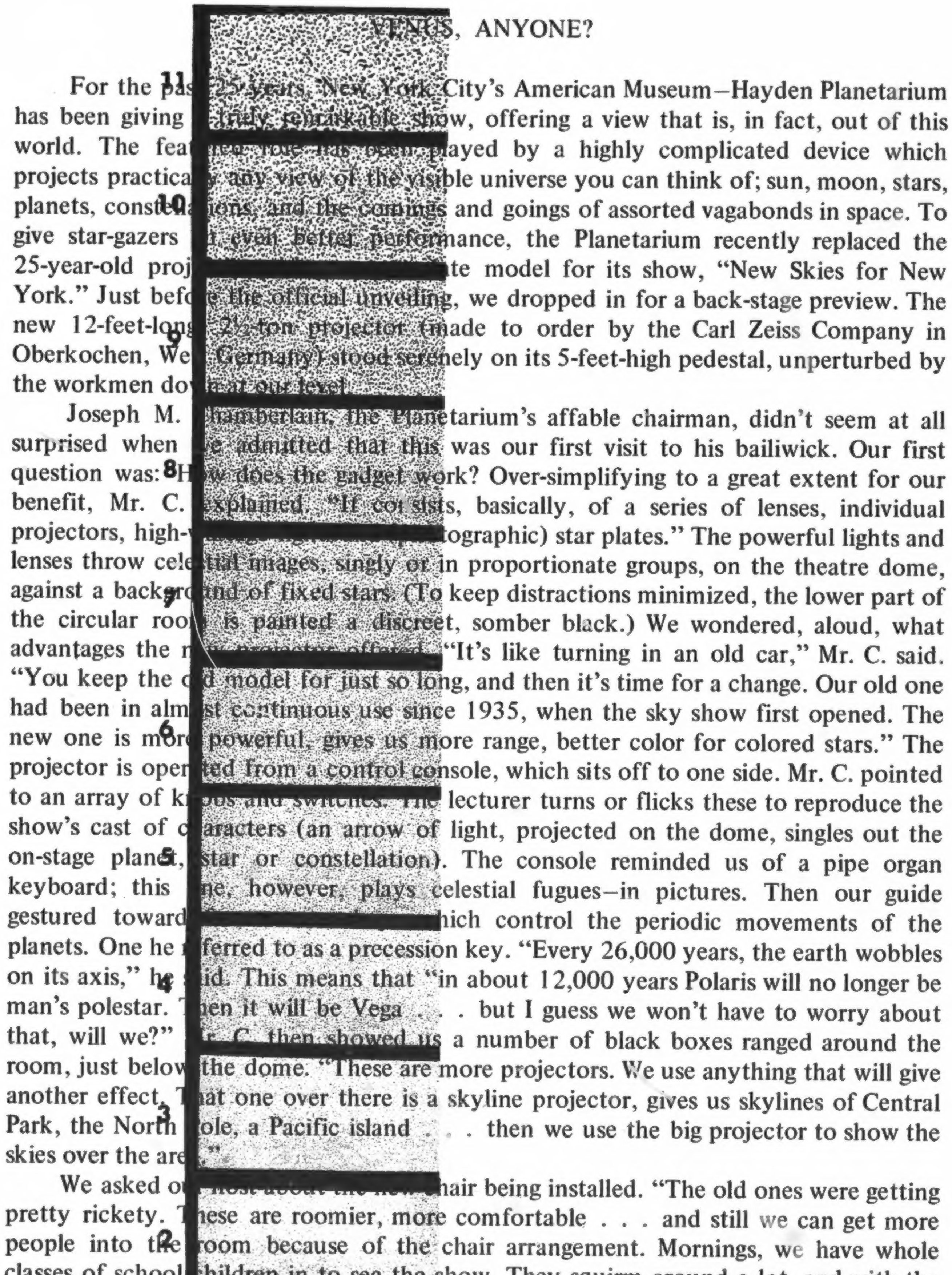
[3] Harold J. Fromm, "Methods for Controlling the Quality of Microimages in Microreproduction Systems," Proc. of NMA, 1965.

[4] This same pattern was used in the evaluation of library volume characteristics, Appendix D.

[5] Format No. 7086, Graphic Products Corporation.



VENUS, ANYONE?

For the pas[illegible] 25 years, New York City's American Museum—Hayden Planetarium has been giving [illegible] truly remarkable show, offering a view that is, in fact, out of this world. The fea[illegible] played by a highly complicated device which projects practica[illegible]y any view of the visible universe you can think of; sun, moon, stars, planets, constel[illegible]ions, and the comings and goings of assorted vagabonds in space. To give star-gazers [illegible]n even better performance, the Planetarium recently replaced the 25-year-old proj[illegible]te model for its show, "New Skies for New York." Just bef[illegible]e the official unveiling, we dropped in for a back-stage preview. The new 12-feet-long 2½-ton projector (made to order by the Carl Zeiss Company in Oberkochen, We[illegible] Germany) stood serenely on its 5-feet-high pedestal, unperturbed by the workmen do[illegible]n at our level.

Joseph M. [illegible]hamberlain, the Planetarium's affable chairman, didn't seem at all surprised when [illegible]e admitted that this was our first visit to his bailiwick. Our first question was: H[illegible]w does the gadget work? Over-simplifying to a great extent for our benefit, Mr. C. [illegible]xplained, "It consists, basically, of a series of lenses, individual projectors, high-[illegible]tographic) star plates." The powerful lights and lenses throw cele[illegible]tial images, singly or in proportionate groups, on the theatre dome, against a backg[illegible]und of fixed stars. (To keep distractions minimized, the lower part of the circular roo[illegible] is painted a discreet, somber black.) We wondered, aloud, what advantages the n[illegible] "It's like turning in an old car," Mr. C. said. "You keep the o[illegible]d model for just so long, and then it's time for a change. Our old one had been in alm[illegible]st continuous use since 1935, when the sky show first opened. The new one is mor[illegible] powerful, gives us more range, better color for colored stars." The projector is oper[illegible]ted from a control console, which sits off to one side. Mr. C. pointed to an array of k[illegible] lecturer turns or flicks these to reproduce the show's cast of c[illegible]aracters (an arrow of light, projected on the dome, singles out the on-stage planet, [illegible]star or constellation). The console reminded us of a pipe organ keyboard; this [illegible]ne, however, plays celestial fugues—in pictures. Then our guide gestured toward[illegible]hich control the periodic movements of the planets. One he [illegible]ferred to as a precession key. "Every 26,000 years, the earth wobbles on its axis," he [illegible]id. This means that "in about 12,000 years Polaris will no longer be man's polestar. T[illegible]hen it will be Vega . . . but I guess we won't have to worry about that, will we?" [illegible] a number of black boxes ranged around the room, just below the dome. "These are more projectors. We use anything that will give another effect. T[illegible]hat one over there is a skyline projector, gives us skylines of Central Park, the North [illegible]ole, a Pacific island . . . then we use the big projector to show the skies over the are[illegible]."

We asked o[illegible]hair being installed. "The old ones were getting pretty rickety. T[illegible]hese are roomier, more comfortable . . . and still we can get more people into the [illegible]oom because of the chair arrangement. Mornings, we have whole classes of school[illegible]hildren in to see the show. They squirm around a lot, and with the old chairs it was [illegible]crickets turned loose." Before leaving we asked if the earth satel[illegible]te launchings had started any kind of stampede to the 800-seat sky theater. "After [illegible]putnik," he said, "there was a flurry. Attendances went up for a while. But then [illegible]hey leveled off." Even leveled off, yearly attendances run into the hundreds of thou[illegible]

Figure C-1. Random Grain Pattern Overlay on Presentation Containing 11-Point Press Roman Type Style. Readability ≈ 7; Visibility ≈ 6.

with no hesitation or confusion. Visibility was defined as the highest step through which the print could be unambiguously recognized, with emphasis on the single printed character, or particular groups of characters, as opposed to words containing the characters. The weakness in this approach is that the evaluation is subjective; each individual making evaluations has a different criteria that operates for him consistent with the definitions. Thus, the ranking of quality indexes from several evaluators is required, particularly when document variations are subtle.

USES OF THE RANDOM GRAIN PATTERN

The grain pattern was employed as a quality indicator for each of the studies in which students were using the readers. This use allowed the particular presentation to be related to the hardcopy from which it was created and, further, allowed presentation comparisons to be made between readers without technical qualification. The quality indices are summarized in Table C-1 for each study, with the values reported corresponding to the steps in the grain pattern in Figure C-1. The values presented represent the quality of the materials used, not necessarily that obtainable. For instance, in the "Fatigue Study," the image at 150x was degraded three steps for purposes of the experiment. In establishing the data for this table (Table C-1), three observations of significant importance were recorded. First, it was possible to improve the readability of the material by microform presentation; a reader with high screen illumination, operating at 32x, consistently gave this result. Second, positive "blow-back" improved readability only at the lower reader magnifications; above 100x, the readability was consistently reduced with positive blow-back. When a 120x fiche was evaluated at 120x, and then at 150x, the readability index would decrease 1 to 2 steps in the latter case. This appears to be primarily a machine effect due to lower screen illumination associated with the higher magnification. Third, referring to Figure C-1, this material had essentially the same readability index irrespective of reduction ratio and reader machine combination, and the index value was equal to that of the hardcopy. (See Performance Study listing in Table C-1.) This singular result is attributable to the excellent legibility of the prepared material.

The grain pattern was also used in the library volume characterization study (Appendix D). In this study, the typographical characteristics of the books sampled were evaluated by grain pattern, Table C-1. Quality Indices for Studies Conducted

Study	Material Used	Quality Index (Scale, 1 to 11)							
		Hardcopy	Readers (Magnifications)						
			46x	38x	115x	150x	120x	32x	150x
Performance Study (Appendix B)	Specially prepared monographs set on IBM Selectromatic (25 pages)	R=7 V=6		R=6.6 V=4.4	R=6.6 V=3.1	R=6.2 V=3.5			
Fatigue Study (Appendix E)	1931 Edition of Works of Mark Twain (50 pages from Huck Finn)	R=6.5 V=5.2	R=6.6 V=4.8						R=2.5 V=0.5
Acceptance Study (Appendix F)									
Contrast:	Monographs	R=7 V=6	R=7.2 V=5.2	R=6.7 V=4.3					
Search:	Complete volume: Personal Finance	R=6.7 V=5.6			R=6.6 V=3.1				
Preference:	Complete volume: Insights into Literature	R=6.7 V=5.6	R=6.4 V=2.6	Neg. Image			R=5.1 V=1.6	R=7.6 V=4.7	

operating to give a visibility index. This index complemented the determination of the individual typographical variations and was undertaken in order to establish if the visibility index did, indeed, characterize the typography of the document. An approximate linear regression equation was developed which shows that visibility index is related to contrast, type size, stroke width, and stroke spacing. The equation, based only on the average typographical measurements per index class, rather than the regression of the individual measurements from each sample taken, is strong evidence of the utility of the technique and suggests that the technique could be developed as a uniform tool for the microform industry. The equation:

$$\text{Visibility index} = -9.39 + 7.45c + 0.46t + 0.27b - 0.13s$$

where:

c = difference in reflection density between print and background

t = type size, in points

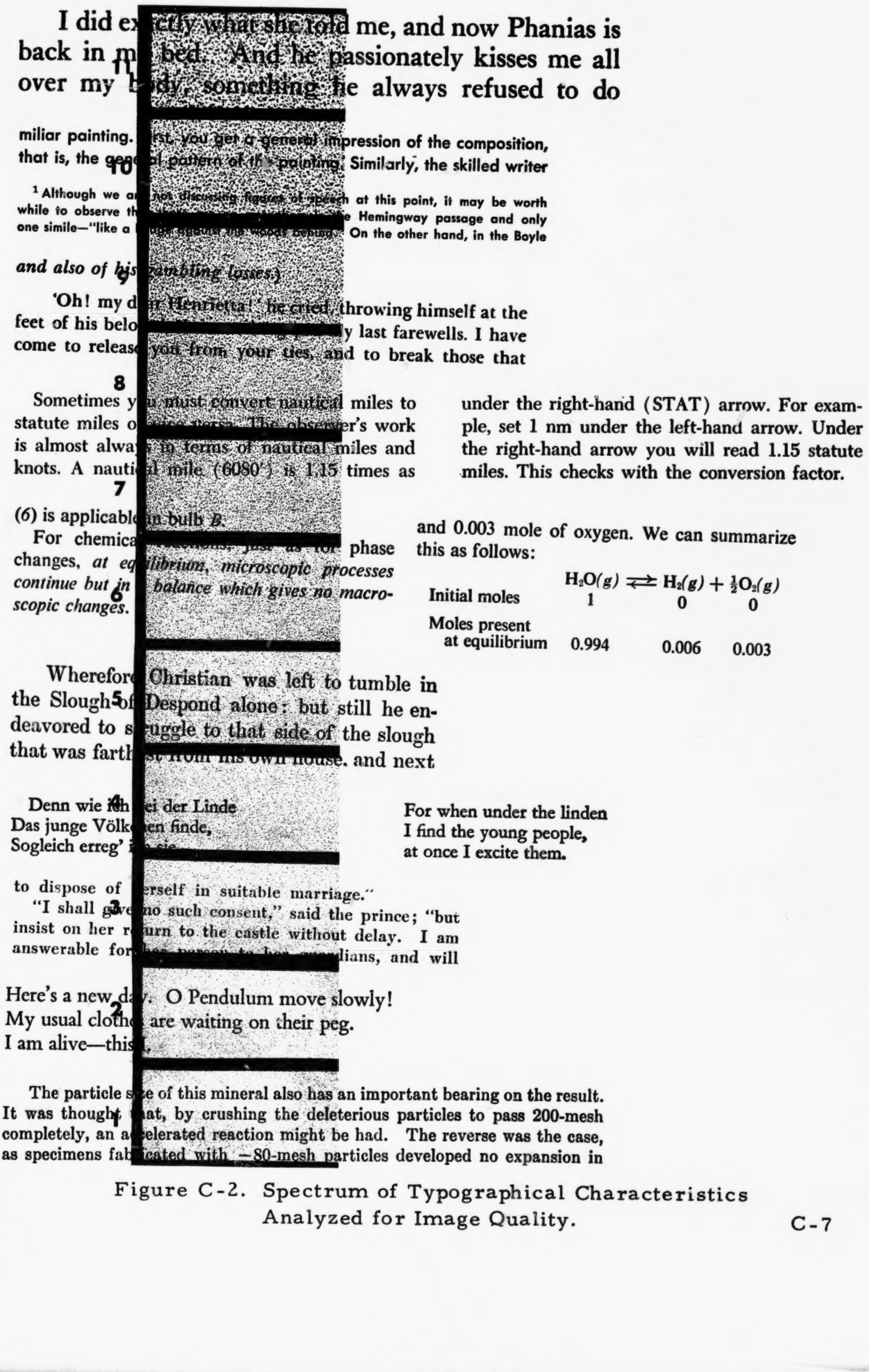
b = stroke width of small "e" bar (0.001 inch)

s = stroke spacing within "e" (0.001 inch)

This preliminary development does not include all typographical characteristics that are of interest. The dependency of index value on spacing between letters, leading, paper weight (as it affects the "show through" of print on the reverse side), and uniformity of print has not yet been investigated, although the data base now exists. These parameters can be expected to modify a predicted index value, particularly if extreme combinations are encountered.

A third use of the grain pattern as a quality index was in a study where materials were selected for filming that represented the spectrum of typographic variation. Examples from the material selection are presented in Figure C-2. The objective of this study was to obtain a quality comparison between the hardcopy and the material as presented on readers operating at high magnification. This comparison was prompted by the fact that all the original materials used in the studies (with students) were of good quality, certainly possessing high legibility in the conventional sense. Thus, further insight was needed into the image quality obtained with materials having diverse typographical characteristics, particularly when these materials were combined on a single film card.

3


11
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1

I did exactly what she told me, and now Phanias is back in my bed. And he passionately kisses me all over my body, something he always refused to do

miliar painting. First, you get a general impression of the composition, that is, the general pattern of the painting. Similarly, the skilled writer

[1] Although we are not discussing figures of speech at this point, it may be worth while to observe th[illegible] e Hemingway passage and only one simile—"like a [illegible] against the woods behind." On the other hand, in the Boyle

and also of his gambling losses.)

'Oh! my dear Henrietta!' he cried, throwing himself at the feet of his belo[illegible] y last farewells. I have come to release you from your ties, and to break those that

Sometimes you must convert nautical miles to statute miles or vice versa. The observer's work is almost always in terms of nautical miles and knots. A nautical mile (6080′) is 1.15 times as

under the right-hand (STAT) arrow. For example, set 1 nm under the left-hand arrow. Under the right-hand arrow you will read 1.15 statute miles. This checks with the conversion factor.

(*6*) is applicable in bulb *B*.

For chemical reactions, just as for phase changes, *at equilibrium, microscopic processes continue but in a balance which gives no macroscopic changes.*

and 0.003 mole of oxygen. We can summarize this as follows:

	$H_2O(g)$	$\rightleftharpoons$	$H_2(g)$	$+$	$\frac{1}{2}O_2(g)$
Initial moles	1		0		0
Moles present at equilibrium	0.994		0.006		0.003

Wherefore Christian was left to tumble in the Slough of Despond alone: but still he endeavored to struggle to that side of the slough that was farthest from his own house. and next

Denn wie ich bei der Linde
Das junge Völkchen finde,
Sogleich erreg' ich sie,

For when under the linden
I find the young people,
at once I excite them.

to dispose of herself in suitable marriage."

"I shall give no such consent," said the prince; "but insist on her return to the castle without delay. I am answerable for her person to her guardians, and will

Here's a new day. O Pendulum move slowly!
My usual clothes are waiting on their peg.
I am alive—this I.

The particle size of this mineral also has an important bearing on the result. It was thought that, by crushing the deleterious particles to pass 200-mesh completely, an accelerated reaction might be had. The reverse was the case, as specimens fabricated with −80-mesh particles developed no expansion in

Figure C-2. Spectrum of Typographical Characteristics Analyzed for Image Quality.

The methodology for comparison was to have the materials ranked for readability and visibility for both hardcopy and machine presentation by the five members of the project staff. Variations in ranking could then be analyzed for physical basis and significant differences traced for cause. The results of this comparison are presented in Tables C-2 and C-3.

Particular comparisons between and within these tables suggest the following generalizations:

1. As a predictive tool, the grain pattern, operated in the readabilitymode, appears to be useful. The only violence done in the overall ranking of material in hardcopy as compared to the screen rankings is attributable to low paper reflectance (material F), and the sans serif type style (material B). This lack of accommodation could be improved by decreasing the transmission of the grain pattern steps or by using a correction factor.

2. The concept of information loss, as previously discussed, is evidenced in the differential change in readability as compared with visibility. Visibility decreases with increasing reduction ratio at a rate which is greater than the readability decrease.

3. The visibility determinations appear to be affected differentially between 115x reduction and 150x reduction. Material H, having a nonuniform type imprint, has appropriate visibility at 115x, but the effect of nonuniformity in the type seems to differentially act on its visibility at 150x. There are other examples of this differential behavior having roots in the typography variations. This situation suggests that visibility evaluations may not be the appropriate predictive tool for estimating image quality.

It must be emphasized at this time that the results reported above have value only in a descriptive sense. They reflect on the commercial state-of-the-art and indirectly on the physical aspects of creating high reduction microfilm. They cannot be interpreted in any sense as a product evaluation. The study was organized to comment on the inclusiveness of the high reduction process and to develop insights into the value of a measurement technique that could have general application in microform if developed further.

Table C-2. Readability Index

	Hardcopy*		Readers			
			115x		150x	
	A	8.25	A	8.05	A	6.85
	B	6.95	F	6.60	F	5.00
	C	6.85	C	6.10	E	5.00
	D	6.75	B	6.05	C	4.85
	E	6.50	D	6.00	D	4.80
	F	6.50	E	5.90	B	4.75
	G	6.25	I	5.90	G	4.70
	H	6.20	G	5.75	I	4.00
	I	6.10	H	5.55	H	3.75
	J	6.05	J	5.50	J	3.55
Average without A:		6.46		5.92		4.49

There are four aspects of significant importance in this comparison table:

- Material B, a sans serif type style, decreases in readability with increasing reduction ratio relative to serif styles.
- Material F, having a low background reflectance in hardcopy, and hence a lower index, demonstrates the ability of the photographic process to compensate for contrast deficiencies given that the other aspects of the typography are excellent.
- Material E, from a modern textbook, indicates that the balance of typographical factors in this sort of publication minimizes readability degradation as reduction ratio increases.
- The average index value of materials B through J are indicative of the incremental differences in readability with filming. These differences are approximately one-half step between hardcopy and 115x reduction; two steps between hardcopy and 150x reduction.

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*In the order shown in Figure C-1.

Table C-3. Visibility Index

	Hardcopy		Readers		
			115x		150x
A	6.90	A	4.60	A	4.20
B	5.35	F	4.00	F	1.85
C	5.35	D	2.95	D	1.45
D	4.90	J	2.65	E	1.30
F	4.75	I	2.35	C	1.15
E	4.55	H	2.10	I	1.05
J	4.45	C	1.90	J	1.00
G	4.40	E	1.90	B	0.70
H	4.35	G	1.75	G	0.60
I	4.25	B	1.45	H	0.20
Average without A:	4.92		2.34		0.90

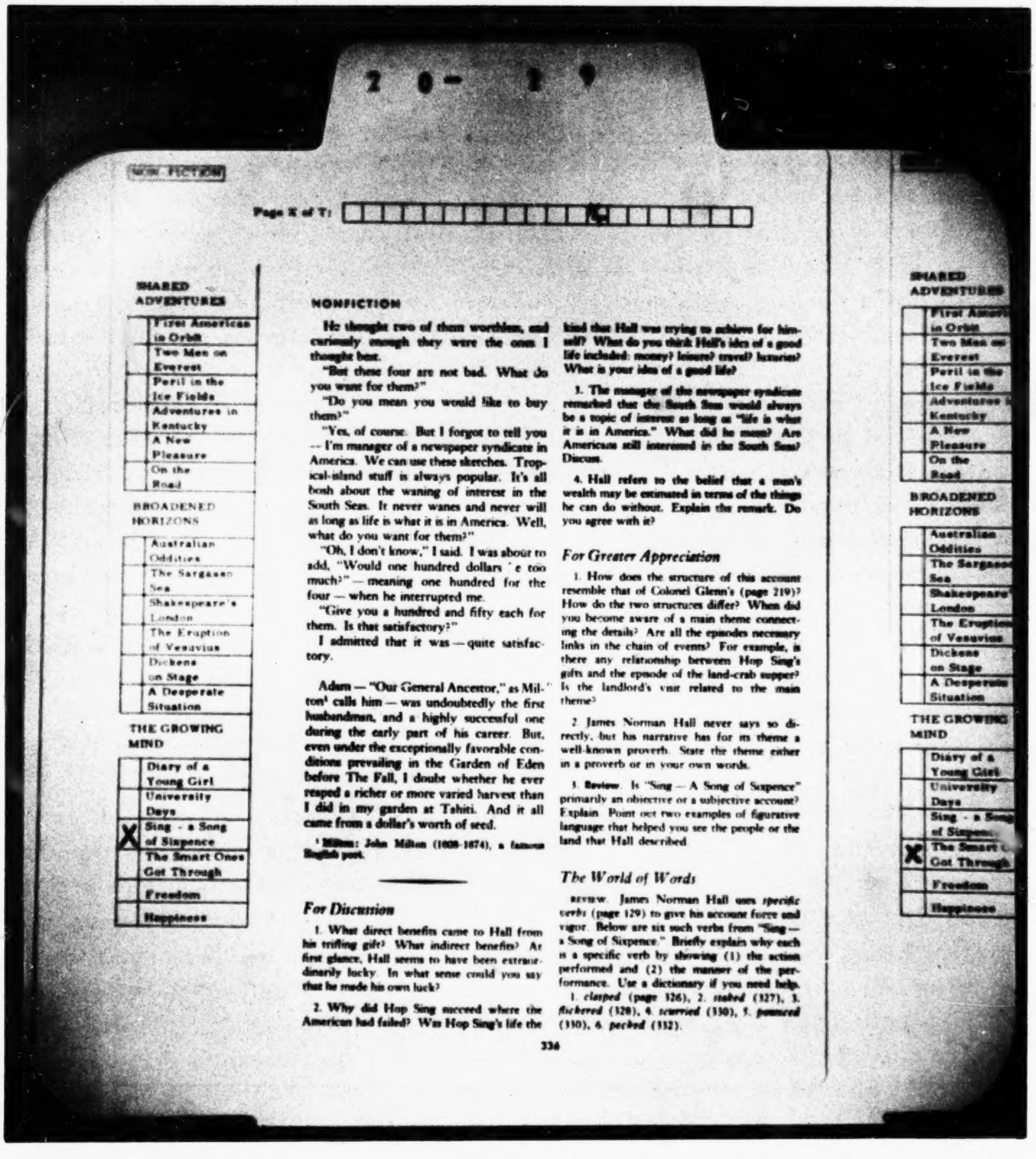
Again, there are four aspects of significant importance in this comparison table:

- Material B, the 9-point sans serif type style shows the greatest decrease in visibility.
- Material F, having low background reflectance in hardcopy, again demonstrates compensation attainable in the photographic process.
- The larger type sizes of A, F, I, show significantly smaller degradation at 150x reduction as compared to that shown by the 9-point type materials (all others): three steps for large type versus more than 4 steps for 9-point type.
- The average index values of Materials B thru J are indicative of the incremental differences in visibility. These differences are approximately 2. 5 steps between hardcopy and 115x reduction; 4 steps between hardcopy and 150x reduction.

FURTHER CONSIDERATIONS

This study has yielded valuable insights into a host of questions that confront the publisher, producer, and user of educational microfilms, as well as establishing a possible point of departure for both an evaluation technique and a philosophy concerning educational microform use. This technique for evaluating image quality shows that the visibility of a high density presentation decreases faster than readability of the same material. But, where are we on the scale of utility? Let us return to the original definition of legibility. Suppose one were to make a hardcopy duplicate of material H on a reader-printer operating at 150x magnification. It is our estimate that testing with this copy would show decreased speed, accuracy, and ease of reading, i.e., poor "legibility." Here, we are deliberately linking the visibility index value with the ability to create hardcopy having legibility equal to the original. This approach is trivial. The application of high density microform in education is concerned with the readability of educational material as presented on a reader screen; this quality is remarkably preserved in present technology. Figure C-3 is an attempt to demonstrate this point. The face of a reader operating at 115x has been photographed. The material presented on the screen has a wide range of type styles and sizes. The readability index for this presentation is 6.6 and the visibility index is 3.1. This illustration should not only convey the quality of the image, but should give the audience a "feel" for the evaluation technique presented here as it differentiates the presentation quality of material used in the studies with student subjects.

The concepts of visibility and readability as developed in terms of the random grain pattern appears to be extremely useful as a measure or index of image quality. This utility is appreciated when it is understood that the use of the microform image dictates the appropriate quality measure. In a system design where the use focuses on a student reading the microform presentations and little hardcopy reproduction is anticipated, then the presentations should be evaluated for readability. Where the use demands significant hardcopy reproduction, the presentations should be evaluated for visibility. The essential difference between the two evaluations can be seen in the reading process itself. The normal reader sees whole words or word groupings rather than the individual characters and then the word. The readability index is a measure of the threshold where the distinctive arrangement of characters composing individual words or pattern recognition of words (in context) fails. While a high index value for image visibility is


2 0- 1 9
NON-FICTION
Page X of T:
SHARED ADVENTURES
First American in Orbit
Two Men on Everest
Peril in the Ice Fields
Adventures in Kentucky
A New Pleasure
On the Road
BROADENED HORIZONS
Australian Oddities
The Sargasso Sea
Shakespeare's London
The Eruption of Vesuvius
Dickens on Stage
A Desperate Situation
THE GROWING MIND
Diary of a Young Girl
University Days
X
Sing - a Song of Sixpence
The Smart Ones Got Through
Freedom
Happiness

NONFICTION

He thought two of them worthless, and curiously enough they were the ones I thought best.

"But these four are not bad. What do you want for them?"

"Do you mean you would like to buy them?"

"Yes, of course. But I forgot to tell you — I'm manager of a newspaper syndicate in America. We can use these sketches. Tropical-island stuff is always popular. It's all bosh about the waning of interest in the South Seas. It never wanes and never will as long as life is what it is in America. Well, what do you want for them?"

"Oh, I don't know," I said. I was about to add, "Would one hundred dollars 'e too much?" — meaning one hundred for the four — when he interrupted me.

"Give you a hundred and fifty each for them. Is that satisfactory?"

I admitted that it was — quite satisfactory.

Adam — "Our General Ancestor," as Milton[1] calls him — was undoubtedly the first husbandman, and a highly successful one during the early part of his career. But, even under the exceptionally favorable conditions prevailing in the Garden of Eden before The Fall, I doubt whether he ever reaped a richer or more varied harvest than I did in my garden at Tahiti. And it all came from a dollar's worth of seed.

[1] **Milton:** John Milton (1608-1674), a *famous* English poet.

For Discussion

1. What direct benefits came to Hall from his trifling gift? What indirect benefits? At first glance, Hall seems to have been extraordinarily lucky. In what sense could you say that he made his own luck?

2. Why did Hop Sing succeed where the American had failed? Was Hop Sing's life the kind that Hall was trying to achieve for himself? What do you think Hall's idea of a good life included: money? leisure? travel? luxuries? What is your idea of a good life?

3. The manager of the newspaper syndicate remarked that the South Seas would always be a topic of interest as long as "life is what it is in America." What did he mean? Are Americans still interested in the South Seas? Discuss.

4. Hall refers to the belief that a man's wealth may be estimated in terms of the things he can do without. Explain the remark. Do you agree with it?

For Greater Appreciation

1. How does the structure of this account resemble that of Colonel Glenn's (page 219)? How do the two structures differ? When did you become aware of a main theme connecting the details? Are all the episodes necessary links in the chain of events? For example, is there any relationship between Hop Sing's gifts and the episode of the land-crab supper? Is the landlord's visit related to the main theme?

2. James Norman Hall never says so directly, but his narrative has for its theme a well-known proverb. State the theme either in a proverb or in your own words.

3. **Review.** Is "Sing — A Song of Sixpence" primarily an objective or a subjective account? Explain. Point out two examples of figurative language that helped you see the people or the land that Hall described.

The World of Words

REVIEW. James Norman Hall uses *specific verbs* (page 129) to give his account force and vigor. Below are six such verbs from "Sing — a Song of Sixpence." Briefly explain why each is a specific verb by showing (1) the action performed and (2) the manner of the performance. Use a dictionary if you need help.

1. *clasped* (page 326), 2. *stalked* (327), 3. *flickered* (328), 4. *scurried* (330), 5. *pounced* (330), 6. *pecked* (332).

336

Figure C-3. Example of Reader Presentation Quality at 115x Magnification

Note: **In creating this illustration, the face of the reader was photographed; the 2- by 2-inch negative was enlarged creating a glossy positive print, which was then screened to make a half-tone negative. A plate was burned from this latter negative and the above copy produced by photo-offset.**

tantamount to high readability (assuming the original material was legible), the converse is not necessarily true. This fact explains why readability is a more uniform predictor of image quality; it is not as sensitive to the mix of typographical factors as is the case with the visibility index.

APPENDIX D

LIBRARY VOLUME CHARACTERIZATION

BACKGROUND

The apparent "fit" between high density fiche and the creation of library collections having large numbers of individual titles can be viewed as an example of form complementing proposed use. But this complement is only important when book-length materials are considered. In essense, then, existing library materials, in book form, represent the reservoir for any immediate high density publishing effort, and no systematic information concerning the physical characteristics of this reservoir presently exists. This lack of data on the physical nature of existing library materials confounds efforts directed toward an understanding of the optimum fit between form and use. This study was undertaken in order to dimension the library reservoir from the viewpoint of a systems designer and, equally important, from the viewpoint of the microform manufacturing specialist.

These viewpoints were unified by developing certain of the necessary data for each interest from the same sample of library volumes. The principal result of this study at this time is the creation of a basic information store than can be analyzed for crucial relationships dictated by particular publishing goals. For example, the creation of a "core" collection of library materials, as opposed to an "historical" collection must reflect consideration of the following differences in book materials based on publishing date alone:

Older volumes tend to exhibit

- fewer pages per volume,
- lower contrast,
- poor paper quality,
- smaller print size,
- sewn bindings,
- greater print show-thru,
- smaller information area.

Such differences are important in the development of a system for a significant microform publishing venture because they affect choice of reduction ratio, fiche design, reader design, and the modes developed for utilization. The technical considerations in the production of high quality fiche, consistent with the different publishing objectives, can be understood only with detailed discussion of the processes involved, but the physical differences in the materials, as tabulated, indicates the range of technical accomodation required.

Certain information was needed specifically to facilitate the conduct of this research program, the information sought was:

1. the distribution of book lengths (number of pages): required as input for cost studies,
2. basic differences in "old" versus "new" materials: affecting image quality considerations,
3. distribution of page sizes: affecting screen size and presentation considerations, and
4. basic typographical data for correlation: affecting the value and mechanism of the random grain pattern technique as an estimator of reproducibility of documents.

The data base for the study was created by sampling the shelf list of the libraries at the University of Denver. Each volume, identified by shelf list card, was then removed from the shelf and physical measurements were made at a station established for this purpose. One researcher performed all measurements and subjective evaluations as required.

DESCRIPTION OF LIBRARY

Within the University of Denver Libraries, there are separate housing and separately maintained statistics for the Mary Reed Library (main library, liberal arts), the Business Administration Library, the International Relations Library, the Law Library, and the Science Library. The public catalog in the main library (Mary Reed) lists all holdings regardless of location. The shelf lists are located in Mary Reed Library and maintained at the present time on cards in blocks of titles categorized as: Dewey list (a general shelf list for a part of the titles), Library of Congress list (a general shelf list for a part of the titles), Law list, Theses list, Microfilm list (up to 14 items per reel of monographs--this list does not include the periodicals on film), and Microcard list (these items are of many sizes and shapes). No periodicals are included in the shelf list. Only one card is maintained in some one of these lists for a single title. Sets of volumes (as many as 50 per set) have only a single title listing. This is also true for multiple copies of a single title. Only a very few of the titles in microfilm or on microcard duplicate hardcopy holdings. No government publications, whether in the form of reports or bound volumes, are recorded in the shelf list. In sampling the University of Denver Libraries, only the Dewey list and Library of Congress list were used, as they comprised the materials of primary interest. About 30,000 titles were ignored in the speical lists.

Library reports show that the University of Denver Libraries had 545,375 volumes in May 1967 and had acquired 32,542 in fiscal 1967-68, ending with 577,917 in June 1968. These figures do include government documents, serials, and periodicals. Of the 32,500 volumes acquired during this 1967-68 period, 34% were books, 23% were microforms (including serials), 25% were government documents, 1% were theses, 11% were serials, and 6% were periodicals. Of the 32,500, 54% went to Mary Reed Library (liberal arts), 5% to Business Administration Library, 26% to International Relations Library, 7% to Law Library and 8% to Science Library. The sample was drawn in January 1969; the total holdings were estimated at 590,000 at that time.

THE SAMPLING PROCEDURE AND CHARACTERISTICS MEASURED

The sampling procedure was one in which the shelf list was sampled by recording every 487th shelf card, in sequence, after a randomized start. The approach was particularly useful because a proportionate sample of the subject matter automatically emerged, and a good estimate of the population was obtained. This stratified sequential sampling procedure is actually considered superior to the simple random sample because the characteristics of interest vary randomly within the strata (each block of 487 titles) yet essential differences exist between strata due to subject matter. Higher precision can be expected in the estimation of population parameters using the systematic sample as compared with the unrestricted random sample because of the equal contribution from each element per strata.[1] While this conclusion is methodologically sound, its validity is particularly evident when one considers that the books are organized in a shelf list based on subject matter only; the characteristics of interest are essentially independent of subject matter, given the subject classification.

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[1] Hold, A., Statistical Theory with Engineering Application, New York: John Wiley and Sons, 1960, p. 495.

In taking the statistics of a sequential sample of book titles from the Dewey and the Library of Congress shelf lists, 418 separate titles were obtained, being approximately 1/500, by linear measure in the card trays, of total titles to be found in these two main lists. This would indicate about 203,500 individual titles in the collection under these two arrangements at the time the sample was taken; of course, the actual number of volumes is larger since many titles have multiple volumes, and often titles are in duplicate copies; 22 titles residing in the Law Library were excluded leaving 396 books in all other subject areas that were evaluated.

The characteristics measured are given in Table D-1. Since these measurements were processed to punch cards, the characteristics are listed in accordance with the punch card column that contains the data. Placed at the end of this Appendix, as Table D-5, is a print-out of the card deck of measurements for the 396 titles, this particular print-out being ordered by the number of pages in the monographs. This print-out, together with the codes (Table D-1) complete the data base sought. ·Having this information on punch cards, it was possible then to order the 396 titles in a variety of ways to study distributions; some of the more important relationships obtained are discussed below.

TABLE D-1. Parameters Measured in Denver University Libraries Sample

Punch Card Columns:	Parameters Measured
1-26	Identification Number in Library Shelf List
27-30	Date of Publication
31-34	Number of Pages in Title
35-37	Height of Book, in centimeters (from shelf list card)
38	Illustrations: 0 = no; 1 = yes (from shelf list card)
39-40	Graphics: 39: 0 = no; 1 = yes. 40: 1 = line drawing (graphs, screened illustrations, sketches) only 2 = symbols only 3 = both 1 and 2 4 = has color 5 = both 1 and 2 and color
41	Footnotes: 0 = no 1 = yes (this includes any print smaller than main type of text)
42	Binding: 1 = sewn 2 = stapled 3 = perfect bond
43	Transparency: 0 = no 1 = yes (.03 for tolerance limits)
44-46	Density of show-thru (reflection)

Table D-1 (cont.)

Punch Card Columns:	Parameters Measured
47-49	Paper:
	47: Coating: 0 = uncoated 1 = coated 2 = both 0 and 1 for different pages
	48-49: Thickness of paper stock, micrometer read to 0.001 inch
50-55	Contrast:
	50-52: Print, density (reflection)
	53-55: Paper, unprinted part with no show-thru (reflection)
56-63	Information Area:
	56-59: Height in inches
	60-63: Width in inches
64	Grain reading for text (see Grain Pattern Technique described in Appendix C)
65	Grain reading for footnote (see Grain Pattern Technique descirbed in Appendix C)
66-69	Type:
	66-67: Number of points of type in main text
	68: Type face in text: 1 = with serif 2 = sans serif
	69: Type face in footnote: 0 = none 1 = with serif 2 = sans serif

Table D-1 (cont.)

Punch Card Columns:	Parameters Measured
70	Leading in number of points used in text
71-72	Distance between letters in 0.001 inch, using combinations of the letters pe-po-oo-oe-be-oc-od
73-74	"e" space, being maximum open distance within the letter from bar of "e" to top ~~of letter, in~~ 0.001 inch
75-76	"e" bar width, in 0.001 inch
77-78	Minimum width of stroke used for drawings and graphs, in 0.001 inch (00 = none or minimum stroke difficult to distinguish in screened illustrations and sketches)
79	Uniformity of print, ink texture: 0 = bad 1 = good
80	Classification of subject matter: A = music and art B = biography E = education F = agriculture G = geography and anthropology H = history L = literature M = medicine P = political science R = philosophy, psychology, religion S = natural science T = technology W = military science

Table D-2. Physical Dimensions of Information Area in Titles Evaluated

Width (in inches)

Height (in inches)	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25	5.50	5.75	6.00	6.25	6.50	6.75	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.75	9.00	Number of Titles:
12.00																									1			1
11.75																												0
11.50																											1	1
11.25																												0
11.00																								1				1
10.75																												0
10.50																					2							2
10.25															1		1				1							3
10.00																	2			1								3
9.75																1		1										2
9.50															1													1
9.25													1				1											2
9.00											1			2	2	2	1											8
8.75												1		2	2		3											8
8.50									1			2	3	2														8
8.25									2	1	1	3	2															9
8.00							1		3	1	3	2	1	1		1	1											14
7.75							3	3	7	4	4	1		1														23
7.50							2	7	17		1	2		1														30
7.25							8	10	13		1		1															33
7.00						4	16	8	5	1	1																	35
6.75				1	2	6	32	5	2	1			1		1													51
6.50					3	7	26	2																				38
6.25				1	5	4	7	1	1	1		1																32
6.00			2	6	19	7	5		1																			40
5.75			1	7	14	1	2	1	1																			27
5.50	1		2	4	2	1	2																					12
5.25			3	4	2																							9
5.00			5	2																								7
4.75	1	1	1																									3
4.50				1																								1
4.25	1																											1
4.00																												0
3.75																												0
3.50				1																								1
Number of Titles	3	1	14	27	47	30	104	37	53	9	12	12	9	9	7	4	9	1	0	1	3	0	0	1	1	0	1	395

Table D-3. Average Typographical Characteristics of the Books Sampled: Assembled for Different Publication Periods

	VISIBILITY RATING (Index Value)						
	6	5	4	3	2	1	Totals
NUMBER OF VOLUMES:							
thru 1924	1	1	17	30	14	2	65
1925-1944	1	4	39	54	11	3	112
1945-1959	0	6	34	59	10	0	109
1960-----	2	5	30	62	7	0	106
Totals:	4	16	120	205	42	5	392*
CONTRAST: (Averages)							
thru 1924	1.23	1.20	1.15	1.13	1.03	0.57	1.10
1925-1944	1.34	1.31	1.21	1.17	1.13	1.08	1.18
1945-1959	----	1.23	1.20	1.18	1.23	----	1.20
1960-----	1.39	1.22	1.19	1.18	1.18	----	1.19
Totals:	1.33	1.25	1.20	1.17	1.13	0.88	1.18
TYPE SIZE, points: (Averages)							
thru 1924	14.0	11.0	10.2	9.5	8.6	7.5	9.5
1925-1944	10.0	12.5	10.1	9.5	8.7	9.7	9.7
1945-1959	----	11.6	10.0	9.5	9.3	---	9.8
1960-----	21.0	10.0	9.7	9.4	9.0	---	9.7
Totals:	16.5	11.3	10.0	9.5	8.9	8.8	9.7
WIDTH OF "E" BAR (Averages, in inches)							
thru 1924	.0060	.0070	.0061	.0052	.0041	.0050	.0052
1925-1944	.0120	.0085	.0059	.0059	.0049	.0050	.0059
1945-1959	-----	.0078	.0070	.0056	.0048	-----	.0061
1960-----	.0115	.0064	.0065	.0059	.0049	-----	.0062
Totals:	.0102	.0075	.0064	.0057	.0046	.0050	.0059
HEIGHT OF SPACE IN SMALL "E" FROM BAR TO TOP (Averages, in inches)							
thru 1924	.0200	.0170	.0175	.0187	.0196	.0170	.0185
1925-1944	.0170	.0140	.0168	.0167	.0187	.0206	.0170
1945-1959	-----	.0189	.0155	.0162	.0196	-----	.0165
1960-----	.0450	.0142	.0157	.0162	.0167	-----	.0165
Totals:	.0318	.0160	.0163	.0167	.0188	.0192	.0170

* Four Volumes had incomplete characterizations.

Table D-4. Minimum Stroke in Graphics (Non-print)

Number of Volumes Containing:

Discipline	No Graphics	Line Drawings		Symbols		Draw. & Symb.		Color		Draw, Symb, Color		Totals
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	
Music, Art	1	6	2	--	--	--	6	5	--	--	1	21
Biography	7	1	1	--	--	--	2	1	--	--	--	12
Education	5	2	6	--	1	1	2	--	--	1	--	18
Agriculture	--	1	1	--	--	--	--	--	--	--	--	2
Geography, Anthropology	1	7	1	--	--	--	3	--	--	--	--	12
History	17	32	10	--	1	--	--	8	2	--	--	70
Literature	44	36	6	--	2	--	2	7	1	--	--	98
Medicine	2	1	1	--	--	1	1	--	--	--	2	8
Political Science	29	7	14	--	--	1	18	1	2	--	--	72
Philosophy, Psychology, Religion	11	6	1	4	--	--	5	--	--	--	1	28
Natural Science	2	1	5	1	1	1	17	2	3	--	--	33
Technology	3	2	3	--	--	1	10	--	--	--	--	19
Military Science	--	--	1	--	--	--	1	--	--	--	--	2
Totals:	122	102	52	5	5	5	67	24	8	1	4	395
		154		10		72		32		5		

NOTE: Graphics include screened illustrations where minimum stroke is not measured. These illustrations predominate in the no-measurement category.

Columns: (1) No measurements
(2) Minimum stroke .004 inch or greater.

Results of Library Characterization Study

The reported results of this work have been divided into two categories: those which pertain to the design aspect of creating a microform collection, and those which pertain to the microimage quality. Only total sample characteristics will be discussed and the estimation of population parameters will not be undertaken formally.

As an added insight into the usefulness of this proportional sample, a comparison of the publication dates and number of pages per volume has been made between the Denver sample and a simple random sample of the shelf list of the Fondren Library of Rice University.* Since only the reproduction of the cards (shelf list) of the Fondren sample was made, no further comparisons were available. The Fondren sample data used includes only single volume, single title works in order to parallel the Denver sample. A chi-square test comparing the page distributions of the two samples, under the hypothesis that the population sampled was the same, indicates that the probability of a true difference is only 1 in 4. This probability would reduce further if the Fondren sample had shown actual number of pages per volume instead of just the arabic pagination. Figure D-1 presents this comparison and Figure D-2 compares the respective publication dates of the two collections. The assumption that a sample of the libraries at the University of Denver would be representative of other libraries and, as such, would have general utility, is strengthened by these comparisons.

The frequency tabulation, Table D-2, which relates the respective height and width of information areas found in the sample volumes, indicates that the choice of a reader screen size of 6 by 9 inches would be satisfactory for one-to-one presentation of some 93% of the volumes sampled. This suggests that a small screen size could be utilized to effectively present library material. In turn, this development reflects on reader size, illumination required, heat dissipation, and optical requirements for a reader designed for library materials. Figure D-3

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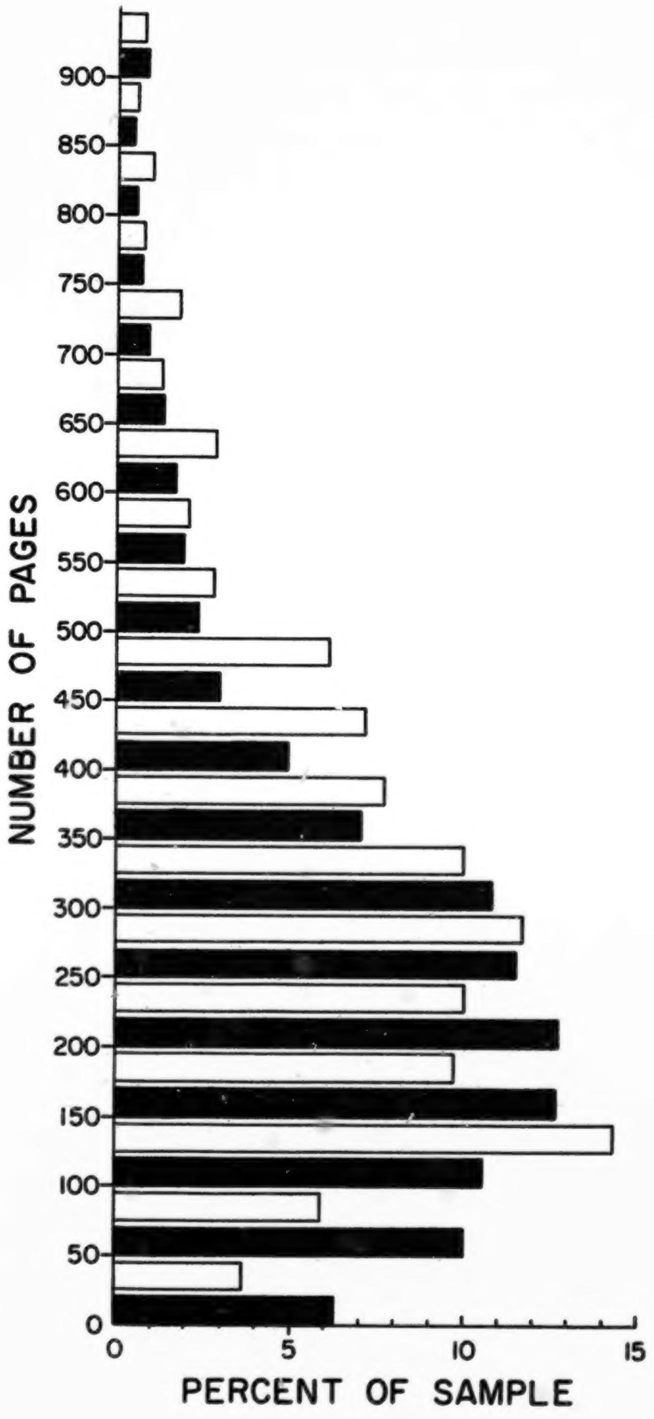
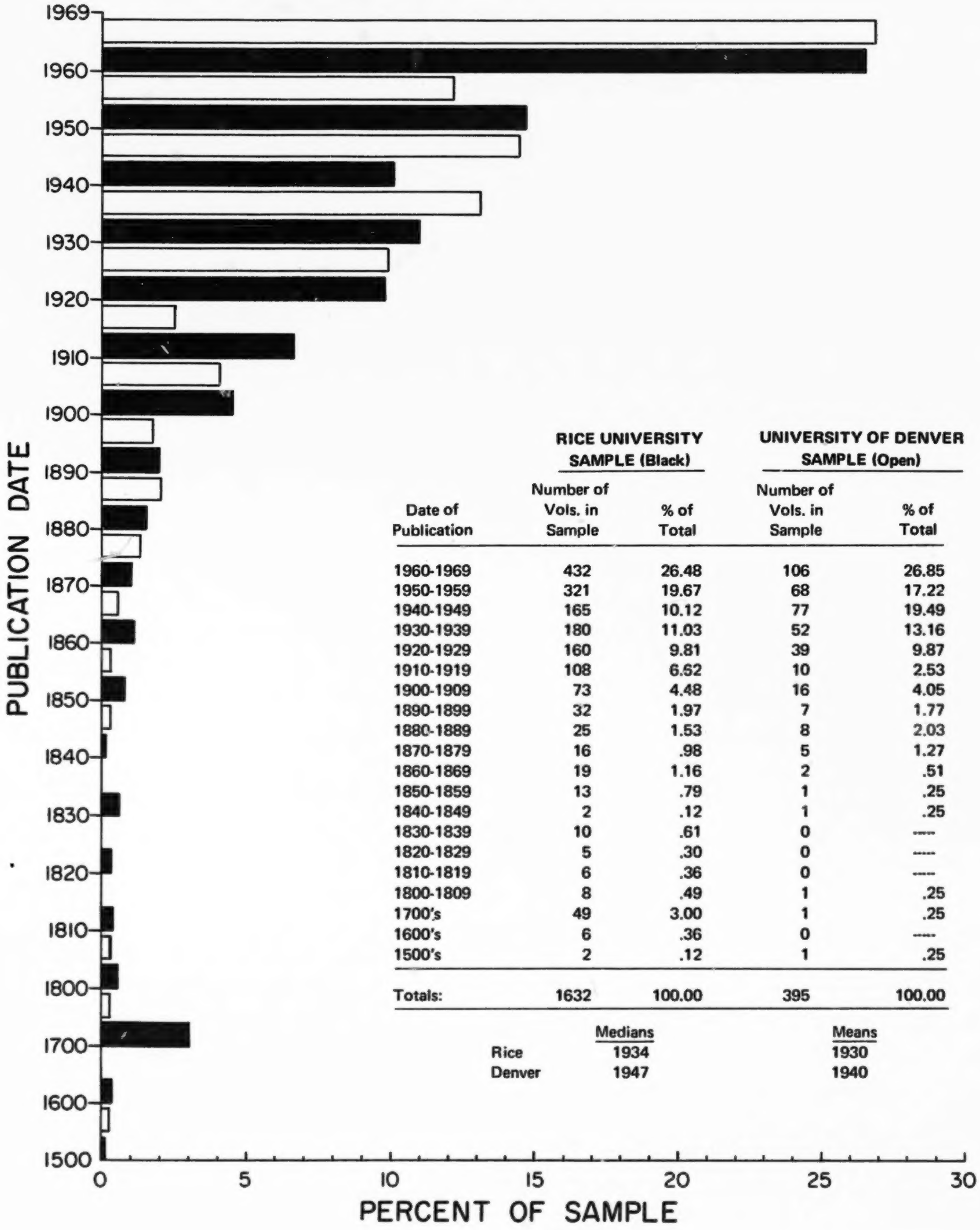
* Prepared by R and D Consultants, Houston, Texas, 1968 under contract to the Office of Education. The size of the Fondern Library was indicated as 500,000 titles at the time the sample was taken.



	RICE UNIVERSITY SAMPLE (Black)		UNIVERSITY OF DENVER SAMPLE (Open)	
Number of Pages	Number of Vols. in Sample	% of Total	Number of Vols. in Sample	% of Total
900---	13	.81	3	.77
851-900	7	.44	2	.51
801-850	8	.51	4	1.02
751-800	11	.70	3	.77
701-750	14	.88	7	1.79
651-700	21	1.33	5	1.28
601-650	26	1.64	11	2.81
551-600	30	1.90	8	2.05
501-550	37	2.34	11	2.81
451-500	47	2.97	24	6.14
401-450	78	4.93	28	7.16
351-400	111	7.02	30	7.67
301-350	171	10.81	39	9.97
251-300	182	11.50	46	11.76
201-250	202	12.77	39	9.97
151-200	200	12.64	38	9.72
101-150	167	10.56	56	14.32
51-100	158	9.99	23	5.88
0-050	99	6.26	14	3.60
Totals:	1582	100.00	391	100.00

	Medians	Means
Rice	242	252
Denver	278	308

Figure D-1. Library Samples Proportioned by Number of Pages.



	RICE UNIVERSITY SAMPLE (Black)		UNIVERSITY OF DENVER SAMPLE (Open)	
Date of Publication	Number of Vols. in Sample	% of Total	Number of Vols. in Sample	% of Total
1960-1969	432	26.48	106	26.85
1950-1959	321	19.67	68	17.22
1940-1949	165	10.12	77	19.49
1930-1939	180	11.03	52	13.16
1920-1929	160	9.81	39	9.87
1910-1919	108	6.62	10	2.53
1900-1909	73	4.48	16	4.05
1890-1899	32	1.97	7	1.77
1880-1889	25	1.53	8	2.03
1870-1879	16	.98	5	1.27
1860-1869	19	1.16	2	.51
1850-1859	13	.79	1	.25
1840-1849	2	.12	1	.25
1830-1839	10	.61	0	-----
1820-1829	5	.30	0	-----
1810-1819	6	.36	0	-----
1800-1809	8	.49	1	.25
1700's	49	3.00	1	.25
1600's	6	.36	0	-----
1500's	2	.12	1	.25
Totals:	1632	100.00	395	100.00

	Medians	Means
Rice	1934	1930
Denver	1947	1940

Figure D-2. Library Samples Proportioned by Date of Publication.

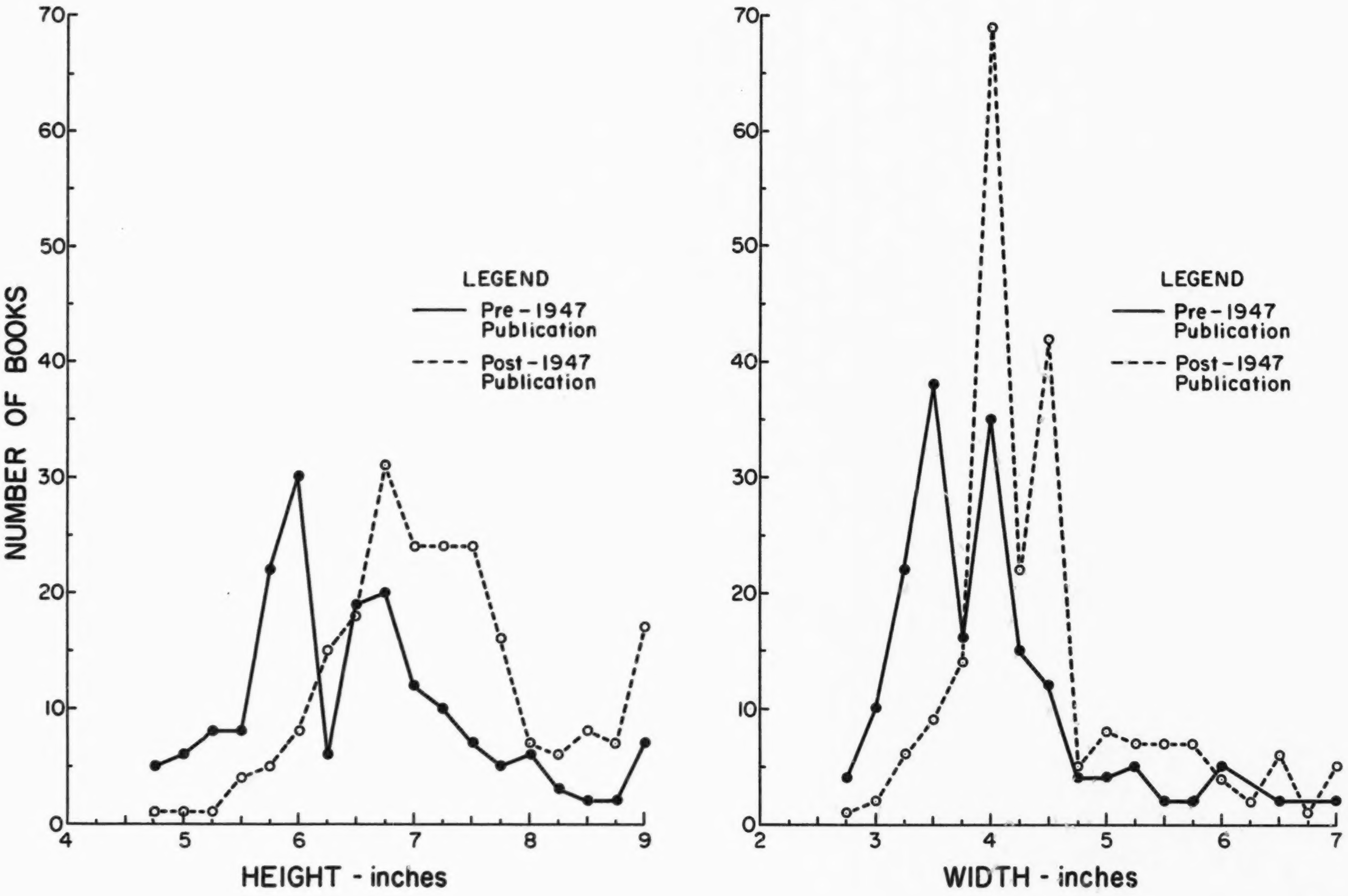


Figure D-3. Differences in Information Area (Height and Width) of Old and of New Books presents an insight into one of the differences encountered when old volumes are compared to new volumes. In this presentation, the height and width of volumes are compared on the basis of pre-1947 and post-1947 publishing dates. The newer materials tend to be both wider and higher; the importance of the publishing objective in the interpretation of system requirements can be seen in this comparison.

The creation of a data base for insights into the technical aspects of making microform reproductions has been complemented by the random grain pattern evaluation which accompanied each analysis made on the sample volumes. This evaluation technique (described in Appendix C) was included in an attempt to establish how it operates as an indicator of document quality. In order to establish the utility of this technique, it is necessary to correlate the pattern index with the characteristics that affect the filming process. Four typographical characteristics have been used in these correlation attempts thus far. These characteristics are:

c = Contrast (reflection density)

t = Type size (in points)

b = width of bar in small "e"

s = height of open space in small "e"

The relationship of these characteristics in the definition of an index value for document visibility can be summarized by the approximate regression equation:

$$\text{Visibility index} = -9.39 + 7.45c + .46t + .27b - .13s$$

This equation is based only on the average values per index class as presented in Table D-3. The characteristics included are not exhaustive in terms of the typography, nor have the individual index values been regressed over the variables considered; therefore, the relationship indicated between variables and visibility index is only a summary one. However, the indication is clear: the grain pattern technique does integrate essential typographical factors into a single evaluation. Further analysis should establish the strength of this evaluation technique. The critical question is, however, "Does the index value for visibility relate the hardcopy quality to an expected image quality?" The modest experimentation described in Appendix C suggests that it does not: rather another index, that of readability is more appropriate.

One area of concern that has not been discussed is the occurrence of illustrations and symbols (described as "graphics" herein) in the books sampled. This is an important area because photo-reduction methods used in modern printing processes can create very fine lines with stroke widths that are lost in the creation of high reduction microimages. Further, the tonal or gray scale response of the microimage is not as great as shown in hardcopy originals. Table D-4 has been included in order to give insight into the occurrence of illustrations, drawings, symbols, and color, differentiated by subject. In addition, those graphics having greater than 0.004-inch minimum stroke width are tabulated separately because this size should present no serious filming problems. Screened illustrations predominate in the tabulation where no measurement was attempted, and the question becomes one of adequate reproduction. The quality that is presently obtainable in high reduction filming is adequate primarily because the viewer has no reference or comparison to draw upon, and the loss of tonal values is low enough so that the viewer is ambivalent. The net result is that fewer than 5% of the volumes sampled has graphics that would present serious filming problems in terms of the communication desired: 1/3 have no graphics, 1/3 have graphics which are suitable for reproduction, about 15% of the remaining 1/3 have graphics with stroke widths of less than 0.004 inch.

The specific results reported above only indicate the value of the information base that accompanies this appendix. Many other distributions and correlations have been ignored which are beyond the scope of this report. The raw data from the sampling process has been included because the range of characteristics measured will provoke questions that have not been discussed. Further, the estimation of specific population parameters can only be undertaken if the sample data is available.

TABLE D-5. Raw Data From Denver University Library Sample

Number of Pages

(396 Titles)

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26  27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
       611      W     788T     19600007170011021020006110016047502754010103101109000L
       842      D     985D     19220018240111020016004118016077505754009101081508001L
       332.414C       734F     19460022280000130013104110012085005753312114142005001P
 TG    500      T       4      19570024240113130010104118008082505252209112071605051S
       630.971L       253      18960027220111010019003123018072504502007101061505000F
 RZ   8985.5    W      65      19610029280011020004105128004092506504008103080906001B
 JPZ     7      J    6443SV    19670032270114030002106134002100007256018106124513001L
       622      M     158F     19580032220113120002107115002070004003210113091506031T
 R9C    71      A       1V55   19620033240014130004104132004082504503208113111505001S
 J     741.642B       879F     1961003426011403000810615400810000650602410 164510001L
       612.397N       277N     19580039250113120006105106005080005503209113101306051S
       556.718L       789G     19450045240111130014002098013067504253209123111704100S
 J     613      N     641PH    19410049210111030010006122010080006505014106091509001L
       020.7    A     824T     19550050220000120007104130005067504005510111071809001B
 HF   1455                     19620051280113120003105130002092505503212113102005081P
       940.5373B      829S     19410067205000030010108110010057503503011106111505001H
       895.11 L       928R     19460068170000130007004132006050003253209112111404001L
       659.133L       847C     19440068220114120004106126004082504503208123122O 5100P
 VM    755      D      94      19070068270113130008104096008077505252209112142403050W
       351.755939A             19620068230011120004104120003075004254309112082008001H
       421.5    P      18F     19230072200000130005105154005057503503209113101905001L
       956.9    R     622J     19500073230111130008206135006077504005410113112007001H
       821      B      62R     19410077250111130006105112003065003755312111100000001L
       759.05   H     747S     19390080260111130004104140004085005502110113072404000A
       811      I      24S     19610082210000010005005114005062503254010103071907000L
       808.5    G    4130      19430083275000130000004134000097506256610112171712001L
       720.92   S     336R     19390083260114130014106130012075005253310116092106001A
       811      P      92P     19120086195011030011007145011055002504009101071706001L
       509.73   G      66      18880088240000130008103112010065004003211113111604000S
       636.085N       277J     19590089250111120006103138005082505003210112092407050F
       294      C     774H     19670090235012130010106130008062504003209114061010000R
       025.3    A      31      19270095235011130007104138007070004253209113091205031B
       330.9787 W    992STU    19560095230113120004104126003072504503309111101606051P
       027.0756N      867L     19480096290113130008104135005097506755512113201510081B
       920      S     557A     19550096210111130006207140006067504004309123111106001H
 RRJ   501      A       2N3    19640098230000130005103136004077504253208111071706001M
       822      A      82B     19290093200000130010008134010050003004308114102005000L
       491.99   C     8754     19260101250113130007104142007075004253210112142205050L
 J     591.1    W     548M         0102260111030004006144005087506504011103112305041S
 M      21.636K         5V2    19600102330013130006105110003107507503309112121107091A
       325.73   G     762      19280103210000130012008126012057503504310112122105000P
 JPZ    10.3    V     658LI5   19020104185111030008106120008047502503009104101404000L
       234.2    B     167P     19440104250000130014004136013072504253310113111407001R
       978.8    S     559P     19510105210000030005005112004070004003010102091505000H
       330.9569 M    948L      19470107240113110009206130007075004504310112101206091P
       818      M     648ZD    19630108220111130008106125008075005253310112061306001L
 M    1004      R 578 OP 36    19330108185013130011104112010062504503311112152308091A
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No. Pages

TABLE D-5 (cont.)

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       812       W      366D    19250109195111130012005132010057503253309112091506151L
       811       C       21RE   18950110175111130006009134006060003754309111121009050L
  HE   821       D      75      19670111240113130004104096001075004503208111071509061P
  JAZ  999       L        4     19640111220111130006107110006062505254312113091807001P
       914.4     C      149     19470112230111121009205065005087506503310114101006001G
  RZ   6725      V        506   19630114220000010005104130004067503755010106052007001B
       943.7     F      389W    19380114190111130008010115008057504253210122111405100H
  LB   2846      S      897R    19470115240011130008005135008070004503210113091606081E
       821       M      628G    19370121200011130008005118006057504502307112091006001L
  JF   515       E        9     19680121230000130005104116004072504503210112112104001P
  J    813       T      536T    19500122220114030006106106006062504004014106101906001L
  LB   1568      G        443   19670123240111030006104128005077504502009103071306001E
  QA     76      B      45      19640123220012030006006130006060003253010103082006001S
       759.4     L      512K    19530123270114110002103146002087506504208224091011000A
       504.062S                 19540124210000030006006132006065003754011103111706001S
  QC   809       M        359   19600124240113130003005125001075004253209113101507061S
  ML     50.5    B        3     19210124260115130010214128008070004005411112121707081A
       778.5     S      596L    19400125190111130007007140007057503504211123121605091T
       281.9     K       38C    19300125190012130011008137010057503254210112111405000R
  LB   2325      C      886F    19490127220000010009005126007067504003312113111705001E
       792       S       46D    19450127240111130010104139008072504504310113151409401G
  RHC  310.5     G       38     19620127175111130012004124010057504003307112121505091P
       709.72    G      381A    19540128320114130009105140005120008505412114101406001H
       334.5     W      811C    19350128230113130008103102007072504502108112111806050P
       330.1     A      215G    19390128195111130006008126006055003504310113101406001P
  TA   480       A        6R5   19500130230113120002103162002087505753309123102005051T
       331.0621I         61SAD  19540131190011110005104115003055004004209112071405041P
       327.73    M       89     19350132210014020017003102014082505252009102152005000P
       791.4     S      235M    19400133210000130015207120015055003253310112151511001G
       973.2     R      783S    19120135210000130007106130007060003503211112072105001H
  JX   1963      S     6458     19670137215000110004106130003060003753211113082105000P
       335       W      855T    19630139210114130004104118004065004002210113091205100P
       759.9492G        613TE   19350140200114130002106126002060004501112112142106001A
       339.4     C      759C    19470140240000120012005142012077504754310112071707001T
  LT   1534      H       24     19110141205115130002104109009065004004211114081411001E
  Z    675       S        3L4   19630142210000130010005138008060003505409113091506001B
  RE   840.6     C        6     19680142280111030004105140003102507502008102081704001H
       572.994B         524FI   19540143230111131011206136006085005254311111101508001S
       136.7            173N    19330143185011130010004122008057503504209113081408001P
  JHV    85      U        5T4   19650144220111130006105133006080005253211113101506001P
       338.5     S      855T    19470145220113110011103136009072504253210113111504111P
  RLB  2369      G        3     19440146210000130010005142008065004003209112041107001E
       266.914H         634F    19410146195111130008209144008075005003310113101406061R
       360.2     M        2     19270148230000130009104124009067504003209113071706001P
  HG   3681      M      337     19640148280013130001105115001090006253309116161706001P
  QA   552       S       65     19630150200113131003104142001060004002109113101305051S
       615.78    H      843R    19570153240113110005103175005070004753110113102106040M
       901       P      849N    19530156240000110008106136006070004254310114082109000H
       914.6     P       34     19380157190000130012107136012057503504311111121505001H
  LC   577       H      715P    19490157240011130009006132008070004004310112082109091E
  LB   875       H      642     19630157220000130006007115004067503503211113101505001E
       364.1     A       21     19280157225000130012005111012067504004210113101906001P
       822.33    EE      14S    19000158280014100016009044016090006000007101061406000L
       581.9648G         96V    19450158250114130006105120006072504504309113101807060S
  LB   1027      Y       17F    19450159230111120006006132006077504003209113091505091E
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TABLE D-5 (cont.)

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     522.19 M     637P2  19380161340113120008104140008095006003210113133003080S
     808.1  L      916T  19610163220011130005006130005065003755510115091007001L
QA     9    M    4513    19650165240113110003105130003077504503209113132405101S
M   1619    M        943H 19040165320113130010204120010107507503311113111108091A
RCR 3891    A        7   19450172190000130015005148014060003504409113071206001H
     843    T     182P   19  0174190000130016004110014055003252209113112304000L
     320.1  H     996P   19590175220000130006007134005062503504210113101508001P
PW  4155    O     713    19660176210111110005105108004065004003210113101605001L
     973.919E      88C   19620178220112130007007135005062504004311113091507091H
     745.67 M    2912M   19570178220114110006105120004060003503210113101206000A
     940.42724    396D   19170179190111130015206113013055004003209116102005000H
     945.05 M     379S2  19490180220000110014005128013062503753309113101006000P
J    813    E      92S   19620131210000030003006140003062504004011103111506001L
     523.89 C     237C   18780182240013130011005118012085004504210112101205071S
     252    S     772ID  18840182190111130009105106009050003002109113112005001R
     338.91 M     655P   19570183220000130005007124004057504003311113061507001P
     155    P     326P   19300183190000130009005106009057503002209112142504000R
QC    16    S     265S37 19670186240012110003105150003075004503210113091205081S
PQ  1917    S       3257 19660189210000130005005130004067504004409116081306000L
     920    K     745B   19360190200111030008206138008060003504010101091506000H
     947.084T     752E   19250190190000130016007100014055003504311112112205000H
J    823    D     579S   19590190220111031008007135004065004004011103092006001L
NB  1097    N       5F2  19630191300111110006107125005115009005311114111505000A
     701.1  H     254S   19490191210000130006005144005065004003310112061905001A
PZ     3    H   45259E   19680193220011030007005137006075005754010104072008001L
     730.951N     532C   19440193285111110005106132005110008254311113081607060A
ML   410    R      88D35 19610195230113130011206132010067504003310112101406101A
     913    I      58    19430197255011130010206136010080006254310112061309001H
     863    P      17M   19450198180000130020005117020060003252209112122006000L
     831    H     615N   18740201165014011020103122014045003252008106111804000L
PS  3521    E      32A17 19620201210011030008105125006060003753009103071506000L
DR   590    J      31    19550202250100130005104128004075004503309112111606000H
JA    98    B      6404  19530203215000130010104110012067504003310113092006000P
QA   268    B       5    19650204240013110003103138003067504254210113091306071S
     355.4  N     216N   19450204215011130017004112016072504003209112142005051H
     172.4  L     574T   19550206230000130011006107009067504003310112101505000P
     230    V     243C   19460206200011130010205130008065 0400330911306140600 1R
MT    68    M      45 1  19630207290013120007106105006090006503210114102206061A
     726.583W     572S   19480208230111130012205111010077504503309112051606000A
     131.307C     971C   19570208215113110004105124004065004004310113141207081R
     808.3  D     434W   19460211200000130012007132012057503754310113101906001L
     793.3  H      33    19400212230111130009105132008060004003209116091406001G
     812    H      25Y   19370212190000030010007112010057503504010103091206000L
     336.20973 M  46ST   19620213240113110004104128003067504003309114091506091P
     133    L     675A   19400214240111110008106135007070004253312112111706001R
LC  4661    Y      58    19670217210111130009106118007065004003210113071506101E
     813    H      21G   19170219205114130007104137007060003504311112071705051L
     614    G      76P   19230220220000030005006134005060003503011103111408000L
     801    A     873F   19430220220300130009004104009065003753209113121205001L
JX  1974    C      49    19650220230000110008105126006070004003210112102008001P
     940.5314     931T   19490221230000130014006116014075004003309113091108001H
F   2845    M    8515    19600224210014110015205079015080005752309110111706000H
     325.26 N     252N   19350225235000130010006122010075004003209112101506001H
     917.83 U      72V   19580225230111130004205116004085005503310113082106000G
     821    S     7447G  19320227205000130005006122005060003503311116111506001L
```

TABLE D-5 (cont.)

	289.3	S	55TH	1914	0227	195111130010207120010060003502209113091604000R
	362.7	A	512C	1956	0229	290113120006104084005102506504410116112010111P
	622	M	63T	1926	0230	205000010010006133010060003254010106102106001L
HX	547	C	6	1963	0233	250000130007006095007077504253211113091906001P
E	169.1	B	46	1963	0233	240000110010007145007072504254309113101805001H
	201	S	757P	1963	0233	220000130006104132004070004003209113101306000R
	330.942	F	28R	1952	0234	240011130008006122008072504253310113102006101P
J	813	W	6893T	1950	0235	210111130006106133006062504255314114132107001L
LB	3607	M	531	1940	0237	210011130008208136008080005254310113091506001E
	658.85	R	845SE	1959	0239	230000030010005105010072504005012102072508001T
TL	699	A	6R3	1959	0240	280111130002105102002090006254210112121010151T
	821.08	C	519	1953	0245	190011130003106102003062504004314112101910001L
	645	W	5	1903	0249	225111130007206130007062504756214113222006001A
	296	S	361W	1960	0251	220000130008006120007067504254410112071506001R
	792.09415	K	215	1950	0252	240111130006205136005072504254311113121905001L
	610.62	C	382N	1945	0252	225000110010005156009067504003309113142107000M
	973.73	W	358S	1940	0254	315111110005104148005100006504311113141906000H
RZ	5784	M	9V5	1953	0255	250000030010204124008075004503007102081106001B
BP	131	K	8	1953	0256	240113130018103100018077504752206118 060R
	832	S	334MR	1904	0257	180011131014104120008052503253209113131706000L
	335.4	M	362T	1936	0257	190113130008105108007060003753209113092405080P
	170	L	517L	1930	0257	195012030011106147010055003004009103071508001R
	301.155792	P		1951	0258	260000130010005138010067504003310112101405001P
	861	D	242T	1931	0259	215000130011005126010060003753310113112005000L
QD	95	A	44	1968	0261	260113110005005136005077505003108113161708051S
TK	7835	S	28	1961	0262	240113110002105114002070004253209123101305051T
	822.08	T	558M	1923	0262	230111130008205118006070003753310112061506000L
TA	157	R	6	1967	0265	240111110003103112003075004504209113092005051T
	914.2	B	176	1927	0266	210111130012208130012057503504311112102206001G
RZ	7234	W	2	1953	0268	230000030006105106006070004004008100101106001B
	919.61	D	284F	1921	0268	230113130011208134011065004253312113101608040G
	550.8	L	487W	1961	0270	220111110002103144002067505503210113121505070S
	862	V	24CA	1942	0270	180011130011005114009050003254309116151507001L
	965	B	421A	1962	0272	220111130007206116007082505253310113101305041H
	396	R	781T	1933	0273	195011130011205140010052503005412113161508001P
	331.2973	W	938E	1943	0273	235113130008106144007072504253209113101804061P
	920	V	331A	1963	0274	240000130006005130005072504253310112101905001H
	917.3	C	772D	1952	0275	220111130009005140008062503504311113091306001H
	347.99	P	279M	1951	0275	230011110008105135008070003753310112102104001P
TN	799	M	304	1952	0275	240113110003104140003075004502209113101905050T
	891.71	P	977L	1946	0278	215000030010004136010065003504011103061607000L
QD	603	C	1G3	1966	0279	240113110005104139005070004503209113121905061S
	361.1	B	289S	1961	0279	210011130005005128004065004004309113071108201P
	111	S	25LFT	1953	0282	210000130010106135008057503253312113092108001R
	843	L	54R	19	0284	160014030012204126010050003002009101081904000L
B	2430.M38	B	28	1967	0284	210000130008105114006067504003209113081006001R
LA	1131	B	55	1961	0285	240012110006105123005070004003210114102106051E
DS	448	L	35	1965	0288	210111110007106132006055003254310112101705001H
	929.8	T	16M	1962	0289	250114000012203142012087506003000100 001H
	460.7	W	6	1929	0291	185000130009005136007052503504311111091507001L
TS	1885	U	6W6	1939	0291	240111110005006140005065004004212113092805001T
	813	C	1HA	1940	0293	215111030007008110007060003504011103071606000L
	338.1	Y	94A	1964	0293	220111110009105124008075004003210112091706071P
	658.31243	K	92F	1942	0293	210111130005104130004062503753211113181505000T
	398.2	Y	566	18	0294	190000030028004108028060003002007101061505000L

TABLE D-5 (cont.)

```
      572.7    B      6      1948 0294 2051131300110051230100625037532101130824061 01G
      913.38   T     81      1936 0295 205111130014106110014067503753209114092105000H
      991.4    S    518S     1939 0297 235111130009207105008075004503209113101505001H
DC    255      C      7G8    1955 0300 2101001300142051200140650 40003309112151805001H
      940.5477L     989N     1952 0301 240011130006104112005070004003309113101806100H
      178.8    L    478U     1942 0302 230011130007209132007067504003211113121708001P
      833      L    677A     1948 0304 220000030011006130011062503504010103121606001L
      193      S     37APH   1937 0307 230012130007006124007062503504310114142605001R
      616.806A      512P     1952 0308 220113130008205135006067504002210112092205001M
L     205      H     84      1937 0309 230113130008104158008072504002109111112105000E
      909.82   C     31I     1950 0310 190111130013005124010055003754309113101506041H
DA     87.1    C      7W3    1968 0310 250111130008105128007067504503310112101805001H
      352.2    G    626M     1926 0311 210000130010007122010065003503309111101509001P
      327.469B      827R     1940 0313 195014130020103108020057503503209114111005001H
PZ      4      G   7972SW2   1957 0314 210000030007006128006060004003009103081506001L
      808      A    468P     1956 0316 220000110006103126006067504003210113101605001L
      954      L    911I     1923 0317 230114130006209115006077504754310111111705041H
      813      K     39T     1934 0318 215111130012007134012065004004310112072005071L
      970.2    D    313R     1935 0319 205114110008205134007060003753310112101608001H
TK   2711      L      9      1954 0320 240113110003104142003072504503209113101207051T
      613.71   T    773R     1943 0321 235111110004104152004070004253111113122604040S
D     511      S      5      1916 0325 220000130007006127007065004254311113112805001H
      920      H    612W     1926 0326 220011130008207144008052503504312114111608000H
LB   2806      C    187P          0329 215111110008104124008065004003210113102106071E
      813      G     34P     1948 0331 220000030010004132010067503753009103101705001L
      333      G      2P     1892 0332 190000110009105094009060003252109113072105000P
      920.7    T    234S     1943 0336 210111130008207124008070005004310113111506000H
      820.8    W    686M     1944 0336 165000131014101140010052503003309111111005000L
PN   3203      K      6      1964 0337 240111110005105117005090005754310113061206001L
      342.739W        6      1904 0337 200000130008105134008057503253309113062206001P
      821      D     48LEG   1887 0338 175000130014105100014052503253209116121605000L
H       1      C    731      1962 0339 260100130005105118003077504503210112071306001P
      841      B     457A    1858 0340 230011110008005130008067503253211116112205000L
JX   1250      V      4      1967 0340 200000131009105124004062504003208110061207001P
      056      M    378E     1942 0341 200111130010102139009060003503109123151704001L
      354.4201 P    174C     1934 0341 225000130011106140011065003754311112111406001P
      818      B     22RE    1896 0342 180111130010206120010042502503209114151505001L
DH    193      P      4      1967 0343 220111130010207120008082505505410112061107051H
      262      S    577N     1963 0345 220011110005104130005067504004210113071408001R
      920      B   3812A     1940 0347 230111110006105126006087505752109113070906060M
GC     21      H      8      1966 0348 240111130004105122003090005753210113102209001G
      656      W    357E     1956 0348 220013110006006144005072504254309113101906101T
F     870      S      7P5    1966 0349 270111110006105124006090006003310113101806001H
      839.82   I     14PI    1939 0354 180000110012104090012052503253209112061305000L
      917.5    D    186S     1938 0356 220111130012206128010065004003110123101505001H
      920      C    321AB    1875 0356 190111130010104120010055003254309114181805000H
QC    173      S    735      1964 0356 230113110005004124003072504504308112101806040S
      224      S    652P     1949 0356 200000130007006112006057503504310113061208001R
PR   6007      U     76T8    1968 0357 220000010006006125006067504004010103091508001L
      891.73   T    989D     1935 0358 230011130008207120009067503753311112111505001L
      331.137K       87U     1937 0359 220113130010006132009070004004309113101406061P
      823      U     49B     1897 0360 200000030012005128012060003004010103101705001L
      813      H     65Y     1936 0361 210000010010007113010062503753009103061507000L
      657.3    M    284      1938 0364 240113110010105112009072504003310112121508091T
      813      R     67D     1921 0365 195011030011205100011060003503009103112005000L
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TABLE D-5 (cont.)

ML	3551	E	49	1924	0367	190113110008106137008047503003210114091408091A
PN	871	L	4	1966	0369	220000110006104108006065004004310113071605001L
	597	N	286	1939	0370	260114130004104138005087505253209111101805001S
	828	L	23T2	1886	0375	190000131012103114008052503253208113102005001L
	823	L	785U	1960	0376	220011010009005115007065003754009104101706000L
	709	B	879S	1963	0379	170111110008106132005085005753210114111605000A
	973	A	737F	1961	0383	210111130006006124006065004003310113101906101H
LB	1647	W	9	1928	0384	235000130013104106010070004003209111101506000E
	658.097471H		311N	1935	0387	230000130010006136008065003753310113101606001T
	920	L	9644AR	1929	0388	225011110010205160010062504005412114111508001H
	813	M	155T	1939	0388	220111130005006124004065004004210112091506001L
	914.92	S	317H	1932	0391	225011130008206136008067503754311113101706001G
	342	B	192B	1946	0391	215000130010005120010067504003209113091106001P
	834	N	7PA	1886	0393	195000110010103112008057503253209113092204001H
	653.07	R	75D	1931	0396	205113130011104118011060004001109113082404060T
LB	1049	C	85	1930	0397	195000110007005103007060003502209113111406000E
	823	W	464C	1925	0399	195000030010005128010057503503009102102305000L
	910.9	H	379P	1923	0400	195111130011105132010057503253309113141505001G
	302	C	5325	1936	0403	220011130006103100005077504503309114131810081P
QC	321	S	37	1955	0404	240113110003104150001075004503109113112004061S
	824	C	875E	1915	0406	180000130006103116006057503253209113101406000L
E	184	A1M	145	1963	0406	240111110007104133006080004754210112112006111H
TP	492	S	53	1949	0409	240113110005104135004072504502209113102204050T
BV	1471.2	T	3	1966	0410	240000110007005132005075004503308113061305001R
	796.4	B	72H	1948	0411	240013130007104122006072504503109113071605071G
	382	G	227C	1964	0412	250000110003104128002072504253310113081505000P
	971.01	N	976	1943	0414	230111110005105128004067504504311113151506001H
	270.6	J	33C	1949	0418	230111130008204124008067504003209113071007001R
	916.3	F	694F	1925	0419	230111131014208144010070004255412112111106001H
	329	B	886A	1927	0419	225111110012006136012067504003310112112205061P
	330.19355	S	755E	1942	0421	230111110008004135008067504004310113091405071P
	823	A	933PR4	1940	0425	220111030009005109008065003504010103071306001L
	218	T	79	1924	0425	205000130011006122010057503503310111092404001R
PS	1120	B	556	1903	0426	200114130008005128007060003504210113091507000L
P	27	M	28	1968	0430	230000130006105140006067504003309113111150500 L
	150.72	C	88	1938	0431	240113110006205130006067504003209113081506111R
PT	175	W	27	1962	0432	230011030007005135005070004004009103091405001L
	323.35	D	912S	1956	0435	240113110006104118004077504252109113111705051P
	137	P	362C	1963	0435	215000010006005126006067504004010103071405001R
	939.45	G	243H	1929	0436	230114030008205134008067503754310111112005001H
	848	R	3937A	1900	0438	190000130014003104014050003003210114152405000L
	813	C	8J	1942	0438	210000030010005132010035003253011102101505001L
HD	6515	T	3J3	1965	0441	240000110007105135007070004254310113081705000P
LB	1589	W	556H	1951	0445	210013110008104123008067504003210113111506061E
	915.6	F	7	1909	0449	225111130014207128012070004004211112082505001H
	309.1	L	98	1942	0449	220113130007205124007070004003310112121705071P
	951.025	C	978M	1903	0454	235111110008005126008080004003309113061705000H
	246	L	92	1906	0457	205111130010104134010060003753209112102404060A
	321.07	A	741H	1961	0458	230000130006005120005070004004310112082007001P
	942.02	S	642S	1925	0459	190111130011005125011057503503208112101208071H
	392.5	D	983W	1945	0461	230111110010104133008067504003209113101906091P
	976.4	W	586D	1923	0462	240111110006206118006067504753211113092804001H
LB	1131	D	71M	1937	0462	210113130008105128007065004003210112112405101E
HF	774	B	5	1966	0465	260113110006103115004082505503208113060513060R
RE	11	C	35	1945	0465	250000110011103121010077505004309113091505000H

TABLE D-5 (cont.)

	823	H	225WD	1958	0468	21000013000810311600607000375431112111906001L
N	5300	G	643	1951	0468	260114130004104156003080005004210114061207000A
	311.2	V	726S	1951	0470	230113110008104122008072504004309112111510051P
HF	5548.2	A	9	1968	0472	240113110007103124007077505003209113071406081P
	981	B	788S	1952	0475	230111130008103134007065004002209113102104001H
QC	612	P	5R8	1960	0476	240113110005105128003075004503209113102205041S
	853	BZ	9P	1943	0477	225011110014005138013067504004409114101305000L
	368	H	87	1913	0477	200011130010104130010060003503309113062206060P
	949.6	W	585L	1944	0482	210000130012005131010067504253210111091706000H
	940.3	H	33	1920	0486	225114110006105125006067504003209114091905001H
	947	O	94	1960	0488	230111110006104100005070004253310111192305001H
	823	S	81302	1897	0489	190000130009004113007060003504409111101505000L
QA	401	D	4	1965	0490	250013110005104122004075004503209113111307051S
	301	D	752	1936	0490	230000110006005128005065004003310113091906000P
	926.1	H	422F	1953	0499	240111110005103126004 75 45 2111112102205000M
	920	P	92T	1864	0504	255111130006104110006072505503211113151505050L
	324.66	M	157F	1960	0508	220111130006105136006067504003209112101205071P
RZ	1231	P	2V48	1964	0509	260000010011107098008090005003007100081506001B
	651	G	819A	1957	0512	240113110004103138004075004253110113101606080T
	920	D	543B	1932	0525	245111130010005142010075004254311123071406001H
QD	412.F1	H	813	1962	0533	270113130004104110004072505003210113092005070S
PR	839	G	7W6	1961	0536	180111110006005104006055003004309112071009101L
	823	C	425DA	1949	0537	200000030008103117007060004003009102101604001L
DS	777.55	H	55	1966	0539	250111110010103132008080004503310112101406081H
	813	P	75T3	1928	0544	185011131017103126012060003504309113141505001L
PR	3770	F	67	1967	0546	240012110006104110004070003754310114051708101L
QA	171	H	8	1955	0553	220113131008103148002065004002109113102205031S
	813	S	59F	1888	0560	195111130018003118018062503502208113112004001L
ML	200	M	8	1951	0561	240111110011104136009067506003310113101505001A
HD	70	U	5G7	1964	0567	240013130004104128003080004503209113101506181P
	917	D	247H	1842	0592	240111110010005118010077504003208112051903001H
QA	931	T	56	1959	0592	240113110003103154002072504503209113102404051S
	571.06	R	81V1	1872	0594	220114110011004122010072504502109111112504050S
	843	D	89J	19	0599	190000010013003138010060003504010101142106001L
	580	F	95	1549	0601	310114130015005120014102506004312111171605080S
JX	4165	M	2	1938	0605	230000110008005129006067504003209113111507001P
	870.9	D	855L	1960	0611	230000130008004126008072504004309112081106001L
	915.18	S	75M	1904	0619	230114130012205125012067504254211113112005000H
	920.02	H	161L	1887	0619	210111110006103130006065004002110113122505000H
RH	45	E	73	1964	0624	250000110005005124003085005253208111061205000P
BF	121	H	25	1965	0625	230115130007103132005075004252209113102005101R
	150	H	5	1931	0629	225113110006104144005070004003309113091606081R
	843	B	215	1931	0643	210111110008103110005060003252208112102204000L
	332	W	445M	1947	0646	240111130010103130009070004503310113161405090P
	190.62	E	26M	1958	0650	250000110007104112005075004503309113101405000R
	920	M	873A	1945	0651	200000130012003126009065004003209113071105001L
	028.5	A	667C	1947	0654	260113130005104114005085005503309113061404081B
HN	980	W	3	1966	0672	240000110009104120006077504503210112112005001P
	342.43	M	435P	1928	0689	240000110008005121007065004004310113132605001P
	616.994	C	874C	1955	0691	260115110003103120002080004502109113111504060M
	331.87	L	89	1929	0703	195011110009103130008057503502110113112505081P
	388.3	H	886M	1958	0712	240113110007104130006072504503210113102105051P
RJN	555	W	5	1958	0713	230011130010103115007072504004409112111506111P
	404	B	854L	1949	0719	240013110006103146006075004503209113071605121L
RPE	675	S	7	1891	0731	245000130008103128008080005003208110091504000L

TABLE D-5 (cont.)

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 HM    51      B      42      19640734235113110005103125004075004503209114091606121P
 DT   513      J       6      19660743225111130007103115004070004503309112111506001H
RZ   2221      G      37      19250769230114131017204134010072504254307111091406000B
     824.08  P      777E      19570774240111130008104122006075004254309113101505001L
     574.97  E       19N      19260792235111110007103102007075004501108110151705081S
 QA   303      M     712      19670803240013110003103126001077505002109113102503071S
     433.2   B      448D      19470809160000130014003054012052503001101110041005000L
     808.8   E      2603      19540813240111110006004116006070004503208110091805001L
 PJ  7510      T       3      19630813240012130006103110005077504503210118      040L
     810.8   H        86      19360873240111131017002115008080005003208112091005061L
     888.1   H      43H4      18970892195114130010103115010060003252108112121604051H
 1J   415      W       3      19390907190113110004103136004060003502108112091803050T
RZ   1000      A      51      19661023230000010009104125008077504753008100091606001B
      920      F    914H      19141122290111110007105124006082504754311112122006001H
 E    483.7    S      76      18761230235111110013104123011067504003209113142005071H
     944.04  P      465H      17961309215011130016004125016067503502210114141702000H
     878.9   G       28A      19281630170000130010103116009050003003308112101505000L
RRC    46      C       4      19632031270115110004103114003087506003209111072205061M
     943.07  S      357G      19482194240000110010204100010072504003109113091906001H
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APPENDIX E

FATIGUE STUDY USING ULTRAFICHE

The basic question of maintenance of reading skills by students, when using reader presentations, has been given an affirmative answer. (See Appendix B.) The reading tasks that comprised this initial experiment were, however, of a specific type: one-page monographs on a variety of subjects. It was of great interest, then, to determine student performance characteristics based on a continuous reading experience. The material selected for this study of fatigue was Mark Twain's The Adventures of Huckleberry Finn, taken from a 1931 edition. The first 50 pages of this novel (often found on college reading lists) were placed on ultrafiche, a length judged sufficient to give between 1-1/2 and 2-1/2 hours of continuous reading.

This particular selection was made because the story line is considered interesting, the reading itself is not difficult, yet the material reflects a great range in content: from straight narrative, to description, to dialect. A major consideration in the selection was the fact that this sort of material represents that of a substantial class of reading demands made on students.

The performance characteristics of particular interest here can be circumscribed by the word "fatigue". But, before the study can be meaningfully described and the results understood, the concept of fatigue must be delineated, particularly as related to the reading task and to the insertion of a machine (or new interface) into the reading task.

READING AND FATIGUE

As early as 1908, E. B. Huey pointed out that reading makes certain severe demands on the psychophysical organism that were not foreseen in its evolution. These demands fall most heavily upon the eye and upon the mental capacities in the rapid functioning of attention, perception, association, etc., and lead to both physical and mental fatigue.

Following the dichotomy proposed by Bartley (1960) two types of fatigue can be distinguished: the subject's feelings of fatigue or subjective fatigue, and objective fatigue referring to performance decrement following repetition of stimulus or response. This distinction is necessitated by considerations of how fatigue is used by individuals in referring to themselves. They may be reporting upon how they feel; that is, they may be saying that they feel tired and unable to perform. Or they may be using the word "fatigue" as a label for an inference. They note certain things about themselves and conclude that these are signs of fatigue. In either case, there seems to be little correspondence between subjective reports of fatigue and performance. A second discrepancy is found in predictions about ability to perform based on physiological studies of input-output relations. Such predictions do not often tally with what the organism as a person is able to do.

Simply considering the sensori-motor activities involved in reading, it is possible to see elements in the task which would lead to fatigue. For example, the stimuli in reading constantly fall on approximately the same regions of the retina, tending to result in the same fatiguing effect found in the after-image phenomena. Although it might plausibly be argued that this is due to adaptation and not to fatigue, this argument would not apply to the cognitive processes active in the reading task.

Ruch (1946) designates any decrement in response resulting from activity as "fatigue" to distinguish it from "adaptation" of a passive receptor. Certainly the cognitive aspects of the reading task would qualify as a type of activity. That reading is a complex process involving cognitive activity has been understood for quite some time. In 1917, Thorndike compared reading with solving a problem in mathematics . . . "The mind is assailed by every word in the paragraph. It must select, repress, soften, emphasize, correlate, and organize . . ." It is interesting to note in this connection that Tinker (1936) found in his studies of eye movements that fixations (not eye movements) take up about 90% of the total reading time in rapid reading and about 95% in slow reading. Stauffer (1969) interprets this as meaning that the mental activity which occurs during the fixation pauses is of more importance to reading than the rate at which the eyes move.

By 1936, the Committee on Reading of the National Society for the Study of Education in its definition of reading assumed that "the reader not only recognizes the essential facts or ideas presented, but also reflects on their significance, evaluates them critically, discovers relationships between them, and clarifies his understanding of the ideas apprehended" (p. 26).

In 1949, this same society describes reading as "essentially a thoughtful process" but one which is more than "thought getting" since it embraces all the higher mental processes: evaluating, judging, imagining, reasoning, and problem-solving.

It seems logical to conclude, therefore, that reading is a complex process involving mental as well as physical activity. Reading fatigue is as much fatigue of the mind as of the eye. An important characteristic is the amount of attention required as well as certain muscular adjustments and tensions of muscles in the neck, head, and eyes.

In relation to the physical aspects of fatigue, Bartley offers this insight:

> "We must always consider the degree of freedom or the degree of restrictedness imposed upon the performer by external conditions when we want to understand the cost of any activity to him. Even when many of his acts are stereotyped by habit they are free from the imposition of formal demands. To the extent that activity is inherently determined within the individual, it can continue for great lengths of time. To the extent that the way acts are to be performed is externally determined, there is likely to be conflict between the demand and the manner in which the acts tend to be performed. There is often considerable discrepancy between the two. The worker subjecting himself to externally imposed requirements is demanding of himself a more difficult order of organization within the neuromuscular system than when free to manifest variety, randomness or even when his habituated activity has the outward appearance of being constrained. Reading tasks are good examples of restricted performance. Eye movements in such situations cannot be of the free wandering sort characteristic of idle, random vision."

Even further restrictions are imposed upon the subjects in the present situation due to the physical characteristics of the reader-fiche presentation. That is, subjects must maneuver the fiche when moving from page to page and refocus from time to time. In addition, they are unable to alter the physical position of the reader itself and must therefore maintain a rather consistent posture in order to interact with the reader. The end result of these and other restrictions form the basis for disorganization of mental process and eventual fatigue.

The manifestation of fatigue can take the form of a performance decrement, a behavioral change, or both. Many researchers, for example Dodge, Freeman, Seham and others, have conceptualized fatigue or subjective feelings of fatigue as playing a protective role in preventing exhaustion. In other words, fatigue is not exhaustion but prevents it and conserves organic equilibrium. Exactly how the organism reacts in order to prevent absolute exhaustion may depend on the situation. If the situation allows it, the most logical preventive measure would be to terminate the activity or take a break, etc. However, the situation may be structured, as ours was, to require completion of the task. The result may be some improvement or simply change in the method used to reach this completion (such as from reading to skimming or scanning). The resultant change in method could be considered a decrement in performance such as that postulated in most definitions of fatigue. That is, the subject is "reading" at a rate different from the optimal rate or, in fact, is not actually reading but skimming or scanning as a method of preventing exhaustion.

Freeman (1939) comments on the peculiarity in many investigations of fatigue of the maintenance of efficiency of output under conditions where a decrement could be expected and suggests compensatory behavior to account for the discrepancy between fatigue and performance. The measurement of performance could be such that the loss of efficiency through discomfort or fatigue was concealed by the change in methods which accompanies prolonged effort in a routine task. Thus, a spuriously constant level of performance may appear in the results due to compensation. In fact, Seham suggests that particularly in mental work, the feeling of fatigue may be experienced when objective measures of production show progressive increase in the amount of work.

No insight into the mechanism and recognition of fatigue would be complete without consideration of the motivation operating. Referring again to Bartley:

> "Any behavior seems to involve two sets of relationships to the environment. One is given in the mere

> descriptions of the immediate interactions themselves. The other is expressed in terms of goals, value systems, and other long-term contextual considerations. Some behavior may be inherent and immediately satisfying; seems immediately gratifying for its own sake. Other forms of behavior will never occur unless there is some sort of "reward" beyond the immediate outcome. Those requiring certain kinds of performance from others seek to include strong rewards not inherent in the immediate situations."

The foregoing introduction to the concepts of fatigue was undertaken in order to establish a context or common reference plane which will facilitate both the description of the experiment and the presentation of results. The essential considerations here are:

1. Fatigue will be present in any extended reading task. The question is, "How much?"

2. Fatigue has two components: objective fatigue seen as performance decrement, and subjective fatigue as seen by the individual himself as an inference about the state of the person in relationship to the task.

3. Performance decrement (objective fatigue) can be associated with higher performance rates due to compensation effects.

4. Motivational set controls the compensation effects. This set can be modified by adjustment (externally) of goals and rewards.

EXPERIMENTAL METHODOLOGY

Twelve students,[1] having had previous experience with the readers, were selected in such a way as to match reading rates in pairs. The objective was to form matched groups which differed only in that Group I was informed that questions would follow the reading experience, while the subject of questions was not discussed with members of Group II. A second dichotomy was performed by having six students perform the reading on a highly readable presentation at unity blow-back ratio, while the remaining six were to use a presentation having a positive blow-back of 1.25 to 1.00. This latter image was also degraded three steps in readability.[2] Figure E-1 presents the two test configurations, and Figure E-2 indicates the effect of image degradation. The difference in presentation quality obtained on the two readers was not shown or discussed at any stage of the test; a student saw only the presentation he was to read, on a reader that he had not used before. The experimental design can be summarized as follows:

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[1] These students participated in the Performance Study (Appendix B) or the Acceptance Study (Appendix F).

Reader Presentation Quality	Motivational Set	
	(Study Group I)	(Pleasure Group II)
(Low)	3 students with knowledge of questions; 1.25 to 1 blow-back at 150x	3 students without knowledge of questions; 1.25 to 1 blow-back at 150x
(High)	3 students with knowledge of questions; unity blow-back at 46x	3 students without knowledge of questions; unity blow-back at 46x

The underlying premise in establishing the matched groups identified by their knowledge of questions or lack of this knowledge was that the questions would tend to stabilize the individual's performance, and possibly cause this group to complete the reading, if completion itself were to be a problem. All students did complete the readings but a striking result was obtained comparing the individual performances of students with knowledge of questions (hereafter called the "Study Group") with the students having no knowledge of questions (hereafter called the "Pleasure Group"). The knowledge that questions were to be asked about the reading was an additional motivator (in the sense of a negative reward) that caused the Study Group to perceive the test in much the same way that they had perceived the monograph reading task: they read for maximum comprehension. However, the group without knowledge read for maximum pleasure consistent with the constraints of the test environment. This result is shown in Figure E-3, where the matched pairs are compared with their respective monograph performances, and the range of variability, as well as reading rate average, is expressed as percentage change relative to monograph average.

The formal analysis of the experiment is restricted by two experimental flaws: Subject No. 5 effectively ignored the page indicator

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[2] A discussion on Image Quality and Readability is found in Appendix C.

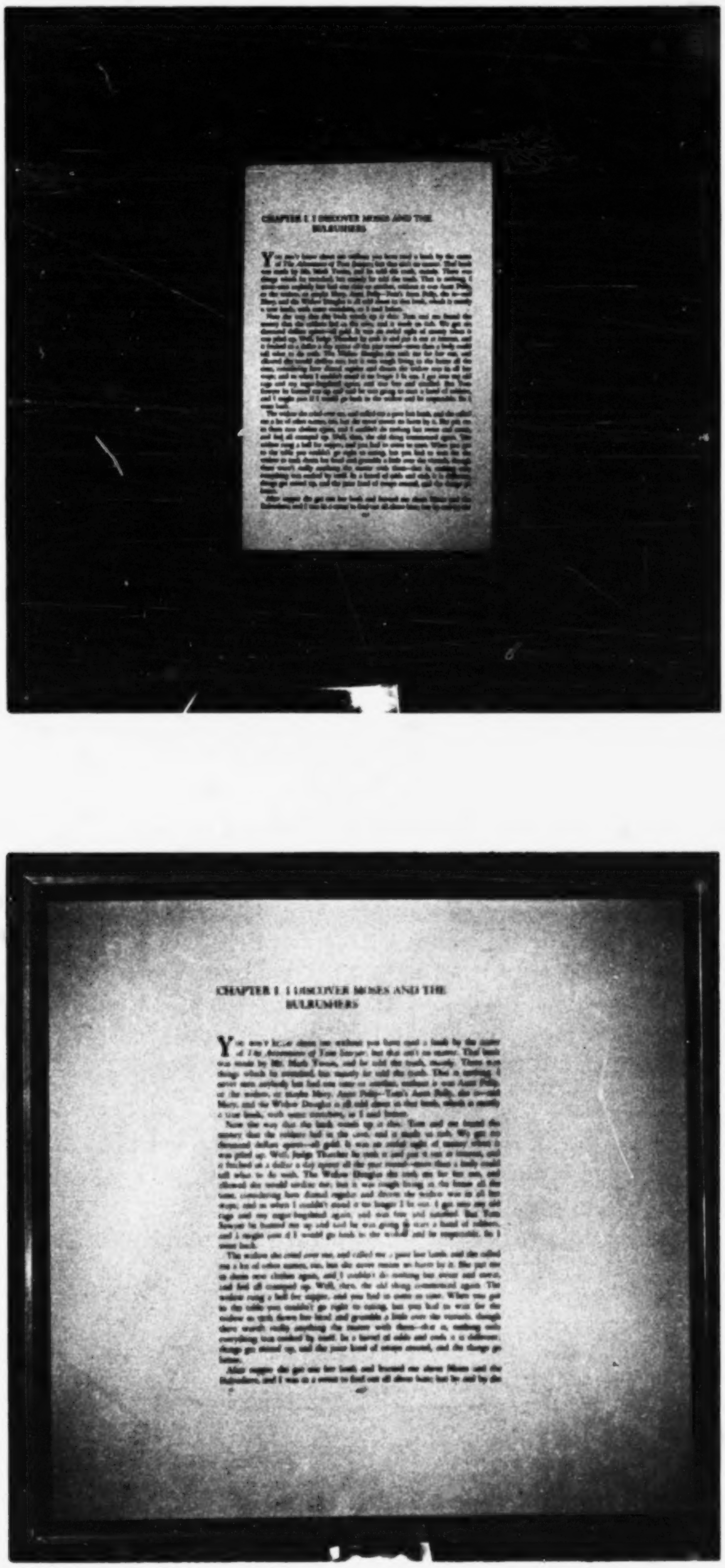
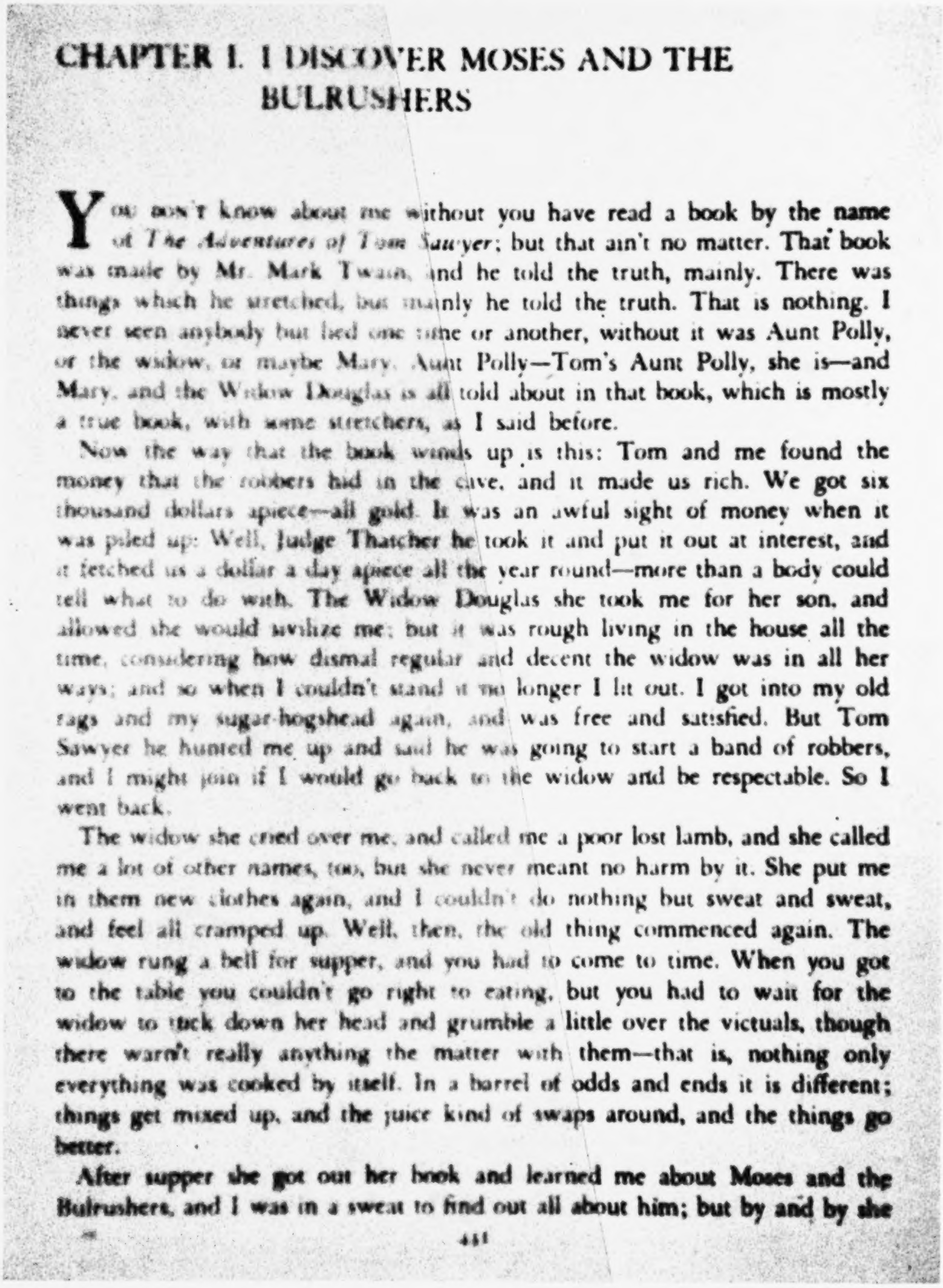


Figure E-1. Comparison of the Two Presentations Used in Fatigue Study



CHAPTER I. I DISCOVER MOSES AND THE BULRUSHERS

You don't know about me without you have read a book by the name of *The Adventures of Tom Sawyer*; but that ain't no matter. That book was made by Mr. Mark Twain, and he told the truth, mainly. There was things which he stretched, but mainly he told the truth. That is nothing. I never seen anybody but lied one time or another, without it was Aunt Polly, or the widow, or maybe Mary. Aunt Polly—Tom's Aunt Polly, she is—and Mary, and the Widow Douglas is all told about in that book, which is mostly a true book, with some stretchers, as I said before.

Now the way that the book winds up is this: Tom and me found the money that the robbers hid in the cave, and it made us rich. We got six thousand dollars apiece—all gold. It was an awful sight of money when it was piled up. Well, Judge Thatcher he took it and put it out at interest, and it fetched us a dollar a day apiece all the year round—more than a body could tell what to do with. The Widow Douglas she took me for her son, and allowed she would sivilize me; but it was rough living in the house all the time, considering how dismal regular and decent the widow was in all her ways; and so when I couldn't stand it no longer I lit out. I got into my old rags and my sugar-hogshead again, and was free and satisfied. But Tom Sawyer he hunted me up and said he was going to start a band of robbers, and I might join if I would go back to the widow and be respectable. So I went back.

The widow she cried over me, and called me a poor lost lamb, and she called me a lot of other names, too, but she never meant no harm by it. She put me in them new clothes again, and I couldn't do nothing but sweat and sweat, and feel all cramped up. Well, then, the old thing commenced again. The widow rung a bell for supper, and you had to come to time. When you got to the table you couldn't go right to eating, but you had to wait for the widow to tuck down her head and grumble a little over the victuals, though there warn't really anything the matter with them—that is, nothing only everything was cooked by itself. In a barrel of odds and ends it is different; things get mixed up, and the juice kind of swaps around, and the things go better.

After supper she got out her book and learned me about Moses and the Bulrushers, and I was in a sweat to find out all about him; but by and by she

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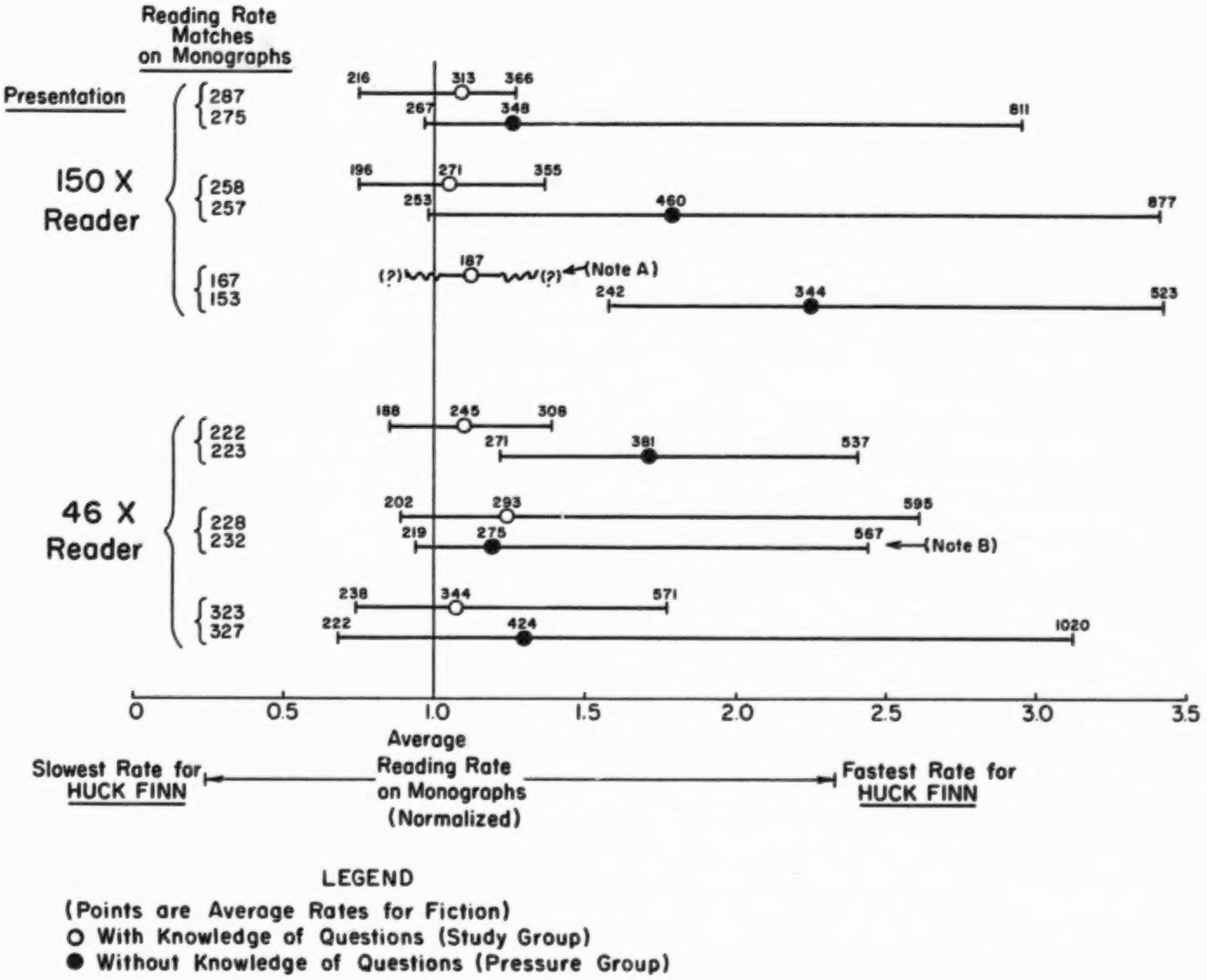
Figure E-2. Effect of image degradation: Left hand portion was used in the study.

Note: **In creating this illustration, the face of the reader was photographed; the 2- by 2-inch negative was enlarged creating a glossy positive print, which was then screened to make a half-tone negative. A plate was burned from this latter negative and the above copy produced by photo-offset.**



NOTE A: Subject essentially ignored page indicator used for reading rate determination
NOTE B: Subject assumed that questions would follow reading

Figure E-3. Increased Reading Rates in Change From Difficult Material to Light Fiction (Huck Finn) switch (this indicator was push-a-button type switch, mounted on the fiche positioning assembly, and coupled to a remote chart recorder) so that only overall reading rate was obtained from his performance; Subject No. 10 indicated that she expected questions, and would have been surprised if they were not forthcoming. These two failings obviate the statistical analysis of the experiment but much insight can be gained in the comparison of performance across the appropriate variables.

PERFORMANCE RESULTS

The overall results of the experiment are summarized in Tables E-1 and E-2. The basic increase in reading rate in this study, as compared to that of the monographs, can be associated with the material itself. Just as there was an average difference of 25 words per minute between the "difficult" and the "easy" monographs, a similar increase was expected when comparing reading rates for light fiction against the average of the monograph rates. Particular attention should be drawn to one performance level presented in Table E-1. A student increased his rate some 125%; while other factors are operative which will be discussed later, the important point is that he told the investigator that he had never read so easily, the story held his interest, and aside from becoming a little tired of sitting in one position, the reader was excellent. His behavior was particularly responsible for the descriptors: Study Group (knowledge of questions to be answered) and Pleasure Group (without knowledge of questions). His previous behavior in reading the monographs emphasizes the role of questions in establishing how the task will be perceived. When he read the monographs, his scores were the most consistent, with the least variance exhibited by any subject. In the monograph work, this student was reading for comprehension (studying); in the fatigue study, he was reading for pleasure.

Three illustrations have been prepared which summarize the essential performance features of this work and comment on the evidence of objective fatigue. In each, the curve presented was established by recording the 3 mean scores (reading rate per page) within each experimental grouping. Five scores were available per grouping for the reasons cited above. Figure E-4 presents the performance of the Study Group and the Pleasure Group in terms of important story line elements. It is clear that both the story elements and the perception of the reading task influence performance. Table E-3 presents the story elements identified in the figure along with the characteristics

Table E-1. Students' Reading Rates and Percent Change

	Motivational Set							
	Students Having Knowledge of Questions				Students Without Knowledge of Questions			
Presentation	Previous Rate	Rate This Study	% Change	Min* Time (mins)	Previous Rate	Rate This Study	% Change	Min* Time (mins)
150x Reader	167	187	+12	146	153	344	+125	80
	258	271	+ 5	101	257	460	+ 79	59
	287	313	+ 9	87	275	348	+ 26	78
46x Reader	222	245	+10	111	223	381	+ 71	72
	228	293	+28	93	232	275	+ 18	99
	323	344	+ 7	79	327	424	+ 30	64

* Minimum Time disregards any time out for positioning; only reading time.

Note: Previous Rate established on reading monographs in Phase I Studies.

Table E-2. Average Percent Reading Rate Improvement from Monographs to Light Fiction

	Motivational Set		
Presentation	With Knowledge of Questions	Without Knowledge of Questions	All Students
120x Reader	8.6%	76.6%	42.6%
46x Reader	15.0%	39.6%	27.3%
Both Readers	11.8%	58.2%	35.0%

Table E-3. Material Content by Page, Huck Finn

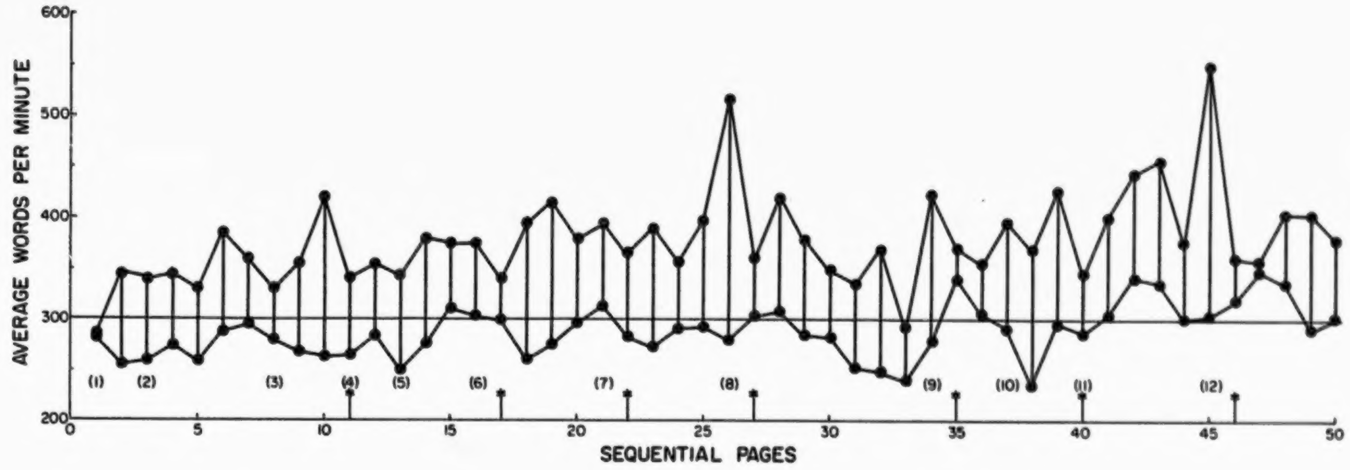
Page	No. Words	Av. Words/ Paragraph	Chapter	Action, Content
1	481	120	(1)	Introduction of characters and Huck's narrative style.
2	621	124		
3	476	95	(2)	Boy's fantasies and games and Huck's realism described.
4	592	118		
5	591	118		(Superstitions)
6	482	25		Conversations of boys.
7	562	43		
8	486	162	(3)	Page begins with new chapter (like Chap. 11)
9	624	308		Huck's literal philosophy of prayer, etc.
10	550	42		Conversations of boys.
11	500	100	(4)	**NEW STORY SITUATION BEGINS; Huck anticipates Father's return and disposes of money.
12	500	28		
13	480	120	(5)	DIALECT. (Superstitions)
14	547	36		Huck's father harranges against world and his son; gets drunk and disorderly.
15	586	38		
16	474	95	(6)	
17	609	122		**NEW STORY SITUATION BEGINS; Huck's imprisonment in hut.
18	635	127		
19	645	161		Huck's father harranges against "govment".
20	625	156		Father is screaming drunk.
21	441	44	(7)	
22	600	67		**NEW STORY SITUATION BEGINS; debris from rising river.
23	602	100		Father leaves with logs; Huck kills pig, wrecks hut, loads canoe, hides under willows.
24	611	153		
25	616	123		Father returns; Huck quickly heads for Island, reaches and settles down on Island.
26	493	82	(8)	
27	600	100		**NEW STORY SITUATION BEGINS; ferryboat searches river.
28	565	81		Huck settles down, explores, finds campfire.
29	600	85		(Erratic action), to Illinois shore, back to Island.
30	465	19		DIALECT, Huck finds Jim.
31	518	29		
32	567	63		DIALECT, Conversations. (Superstitions)
33	533	29		Jim's business experiences.
34	474	53	(9)	Jim concludes story of his investments.
35	475	68		**NEW STORY SITUATION BEGINS; move into cave, storm, flood, marooned animals, frame house drifting by, dead man, salvage from house. (Superstitions)
36	580	58		
37	455	65	(10)	
38	604	101		Jim is bitten by snake; remedies.
39	482	120		Plan for Huck's venture as a girl.
40	425	33	(11)	**NEW STORY SITUATION BEGINS; Conversations with woman.
41	579	64		
42	530	31		Huck's experience in disguise. Conversations.
43	568	44		
44	508	34		Woman explains different manners of boys and girls.
45	460	58	(12)	Disguise sequence ends; Huck and Jim escape Island.
46	605	121		**NEW STORY SITUATION BEGINS; floating down river, gleaning provisions along the way.
47	623	104		
48	556	51		Sight and board wreck of steamboat.
49	544	39		Two men aboard planning to kill a third man.
50	435	40		Huck dashes to leave wreck; Jim says raft is gone.

of the text itself. Figure E-5 is the same data in the form of smoothed curves. This illustration shows that both groups were sensitive to story elements as well as the increased reading rate of the Pleasure Group. Figure E-6 should be compared with E-5 in order to see the effect of the presentation differences. Only at the beginning of the experiment can an effect be seen which can be associated with the degraded image. While there is no statistical basis for establishing significance with this behavior, it is suggested that any cause and effect relationship due to poor presentation is quickly adapted out because the student has no base of comparison in terms of image quality other than the expectation that his previous experience with other readers had created.

Before commenting on objective fatigue and the specific indications seen, it should be stated that the high reading rates of the Pleasure Group can be understood as a mixed reading-and-skimming process. The tabulation of story line elements, Figure E-4 and Table E-3, indicate that another process is being invoked at those places in the story where transition occurs. This should be understood in the sense of "compensation" as developed earlier, and the increase in reading rate (based on time intervals) interpreted as a performance decrement.

OBJECTIVE FATIGUE

The performance aspect of this experiment can now be summarized within the framework of fatigue concepts presented earlier. The structure of the experiment, specifically the threat of questions, caused the reading task to be perceived in two different ways. The group that approached the task as one in which comprehension was the goal presents a "base line" performance against which the group reading for pleasure can be analyzed. Certainly the Study Group experienced fatigue but, within the experimental context, the performance is stable: a trend line toward performance over time shows some compensation effect. The Pleasure Group also experienced fatigue, even though the reading task was perceived as less difficult than was the perception of the Study Group. Thus, the perception of task difficulty is responsible for the basic difference in reading rate but compensation effects are noted in the occurrence of skimming and in the sharply steeper trend line of performance over time. These differences should be manifested as greater variability in reading rate, which, of course, is confirmed in Figure E-3.



Top points = Student's reading rates without knowledge of questions, "Pleasure reading group"
Bottom points = Student's reading rates with knowledge of questions, "Study group"
* = Start of a New Story Situation Sequence (slows down the Pleasure Group consistently, but not the Study Group.)
() = Where a chapter begins; see Table E-3.

Figure E-4. Profile of the Huck Finn Reading Sequence with Median Scores Averaged.

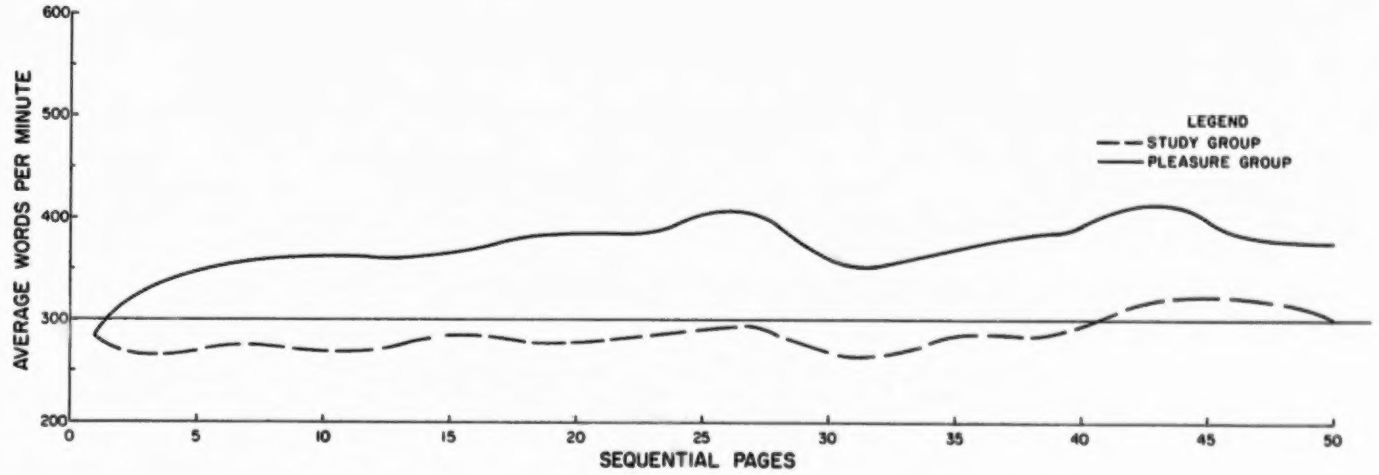


Figure E-5. Performance Differences Based on Task Perception

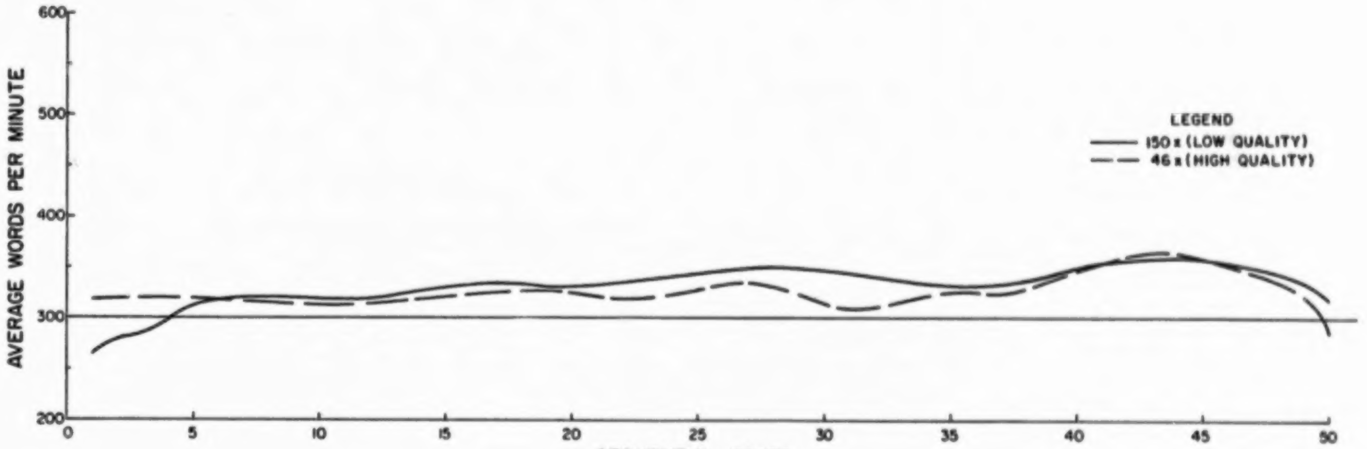


Figure E-6. Performance Differences Based on Presentation Quality

SUBJECTIVE FATIGUE

A variety of questions were asked the subjects at the conclusion of the reading task, in addition to the written questions on the story line. These written questions were answered equally well by all subjects (13 or 14 correct out of a possible 15). These questions were based on material in geometric fashion, one question from first ten pages, five questions on last ten pages of the reading; but, emphasis was on the story line rather than on relationships or abstractions. The questions that probed for information on subjective fatigue are summarized by reader image quality categories as follows:

Questions on Subjective Fatigue

1. Did you become tired and when?

Answer, low quality, 150x reader: Three of the students became tired about halfway through the reading and another mentioned that his eyes became tired but he was not tired physically. People with contact lenses seemed to be more bothered by the sustained reading than others. Again, those who did not become tired thought this was a function of the type of material.

Answer, high quality, 46x reader: Four of the six subjects said they became tired, one right away, two in the middle of the reading, and one toward the end. Two students said that they didn't become tired, or didn't notice it, and thought this was because of the type of material, i.e., the story was interesting and held their attention.

2. Did you feel like giving up or quitting, and, if so, why didn't you?

Answer, low quality, 150x reader: Five of six said that they didn't feel like giving up while one said that he would have, but feared he would not get paid.

Answer, high quality, 46x reader: Four of six said they didn't feel like quitting. The remaining two said that they would have given up or taken a break if not for (a) they knew they would be asked questions, or (b) they were afraid they wouldn't get paid.

Performance characteristics and fatigue comments are presented in the following development, categorized by matched reading rates:

Pair 1, boy and girl, 150x reader

Subject No. 1, boy, Study Group. Did not become tired but explained this as a function of the reading material. Story line was able to keep him interested and he was sorry to have to quit. Did not feel like giving up. He read the first 10 pages at 310.8 wpm (108%) and the last 10 at 328.6 (114%) with the last 5 at 333.84 wpm. The general trend seems to be increased reading rate over time. He showed a dip at 471-475* to 255.36 wpm where Jim did substantial talking.

Subject No. 2, girl, Pleasure Group. She did become tired in about the middle. Her contacts (lenses) bothered her as she'd had them in all day. Did not feel like quitting, however. Her rates also indicate a general trend toward faster reading over time. The first 10 pages were read at 323.3(117%) and the last ten at 415.02 (151%). Again there was a dip to 288.96 on pages 471-475.*

Pair 2, girl and girl, 150x reader

Subject No. 3, girl, Study Group. She became a little tired about halfway through the reading. She attributed this to having to maintain the same position too long (constraints). Didn't really feel like quitting or giving up. Reading rates show a general trend of reading faster with time, 241.33(93%) for the first 10 pages and 304.98 (118%) for the last 10. She read pages 471-475* at about her average rate.

Subject No. 4, girl, Pleasure Group. She liked the story which kept her interest high. She read the first 10 pages at 407.34 (158%) and the last 10 at 540.36 (210%), again indicating a tendency to read faster toward the end of the session. She had a range of 623 wpm and quite a few very fast reading rates to bring the average up.

Pair 3, boy and boy, 150x reader

Subject No. 5, boy, Study Group. Did become tired about halfway through the session. He did feel like quitting but the money kept him in there. He also thought it would do him good to finish a task for once. His record was incomplete but his overall rate was about

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*Page numbers in original text.

20.5 wpm faster than his previous rate. Since his first few pages were consistent or a little below his overall rate, this would seem to indicate a trend toward faster rates over time.

Subject No. 6, boy, Pleasure Group. Kind of tired of sitting in the same position (constraints) but his eyes were not tired. Story kept him interested. Did not feel like quitting. His average reading rate showed a large increase of 191.49 words over previous rates.

Pair 4, boy and girl, 46x reader

Subject No. 7, boy, Study Group. He did become tired toward the end. Would have stopped if he were on his own but the questions prevented him from quitting. His rates were very stable: 245.5 (110%) for the first 10 pages and 235.44 (106%) for the last 10. Did not show an increase over time. No extreme scores in either direction.

Subject No. 8, girl, Pleasure Group. She didn't become tired or feel like quitting since she liked the story. She showed a rather large increase in reading rate and a large range. She read the first 10 pages at 339.24 (152%) and the last 10 at 421.64 (188%) but results indicate more of a spurt toward the end than a general trend toward faster reading.

Pair 5, girl and girl, 46x reader

Subject No. 9, girl, Study Group. She became a little tired about halfway through. Did not feel like quitting, however. She showed a noticeable tendency toward faster reading over time, 244.46 (103%) for the first 10 pages and 392.68 (172%) for the last 10. Her fastest scores were on the last 5 pages.

Subject No. 10, girl, Pleasure Group. She became kind of tired but did not feel like quitting. She thought there would be questions. Her fastest rates were all within the last 5 pages with her fastest score on the last page.

Pair 6, boy and boy, 46x reader

Subject No. 11, boy, Study Group. He did become tired right away - should have worn his contacts. Would have quit if it weren't for the money. Indicated a general trend toward slower reading: 388.10

(119%) for the first 10 pages and 328.98 (102%) for the last 10; 436.96 for the first 5 pages and 312 for the last 5.

Subject No. 12, boy, Pleasure Group. Did not become tired or feel like quitting. Scores were extremely variable with a slight tendency to speed up toward the end.

CONCLUSIONS

Both the subjective and objective aspects of fatigue are present in this experiment. The point of emphasis is that they should be present. The Critical insight comes when it is asked, "Is there more fatigue associated with using a reader presentation than would be expected using hardcopy?" This question must be answered in two parts. In terms of objective fatigue, two levels of performance are evaluated which show no behavior that is inconsistent with the behavior expected if the experiment were repeated with hardcopy; nothing associated with these results suggests that different performances might be obtained and the experiment was not repeated in hardcopy for this reason. However, the subjective fatigue is entirely another matter. The presence of the machine interface does create constraints in just the sense that Bartley* describes: "The worker (student in this case), subjecting himself to externally imposed requirements is demanding of himself a more difficult order of organization within the neuro-muscular system than when free to manifest variety." The "imposed requirements" are reflected in student comment about quitting. Three of the students would have quit if not for the monetary reward or the obligation to answer questions. It is not reasonable to expect this same behavior if the students had used hardcopy, nor was this behavior the result of poor presentation quality--two respondents had the high quality presentation from which to read.

An attack on subjective fatigue should focus on the environment of reader presentation, including the design of the reader itself. A human factors analysis, which integrates the task: reader machine, user, and environment, will lead to minimizing the "imposed requirements." Finally, it is clear that performance can be obtained if formal motivation is present; the design objective can be seen as performance sustained through satisfaction of personal information needs, or unstructured motivation.

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*See first quote from Bartley for full context, at beginning of this Appendix.

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Tinker, M. A., "Time Taking for Eye-Movements in Reading," Journal of Genetic Psychology, 1936, 48, 468-471.

APPENDIX F

FACTORS INFLUENCING THE ACCEPTANCE OF EDUCATIONAL MICROFORMS

The commercial development of ultrafiche, with its potential for recording complete volumes on a single film card, has suggested that microimagery could become a powerful tool in education. Implicit in this concept is a pervasive use of microforms and readers in the "day-to-day" or routine educational pursuits of students. While the particular applications of ultrafiche in education, and the possibilities for implementing educational information needs through this medium are of great interest, these possibilities have been explored elsewhere (Appendix G). It must suffice to say that information systems of great significance can be created using this technology. However, the question of effective use of such systems, is quite another thing. Effective use of a microform information system depends on the satisfactory insertion of a man-machine interface into communication channels that are presently well developed in the educational environment. This implies that the student can utilize the microform presentation efficiently and equally important, that he indeed will utilize the machine presentation routinely.

To expect that microform presentations of educational materials will enjoy routine use is presumptuous at this point, regardless of how well an information system is conceived. The only experience base in education is that of exceptional use: this may be seen in the type of microform material that is presently to be found in library collections. This material includes "out-of-print" works, back issues of journals, newspapers, etc. The appeal to a limited user audience on an exceptional basis is clear, and the use of microforms in research libraries is characterized as generally unsatisfactory. (See a recent study by Holmes.[1]) This negative situation comments on the role of this experience base as a guide in achieving routine use: other than identifying areas of certain failure, this past experience is without significant value. Commercial experience is also of limited value to the educational purpose because the system demands are so widely different from those in education; the information itself tends to be in the form of data, the user task is to locate and access this data, with motivation and success derived from employment. On the other hand, the student's use of microform on a routine basis implies frequent and extended periods of contact in which the communication of subtle and abstract information is anticipated and where the material is "studied" for meaning and implication. Further, motivation for the continued use of the microform must rely on the individual's perception of his educational goals rather than being derived from some formal or structured situation.

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[1] Association of Research Libraries, "Determinations of User Needs and Future Requirements for a System Approach to Microform Technology," by Donald C. Holmes. Washington, D.C. ARL, 19 July 1969 (Interim Report OE, Contract OEC 0-8-080786-4612(095)).

This discussion explains our interest in exploring the factors that influence the acceptability of microforms in an educational setting. At this level, the differences in reduction ratio, reader magnification, etc., are subordinate to the adequacy of the total system. The focus here is on the mechanism of attitude formation relative to the use of microform presentations, with the objective being that of identification and understanding of critical factors. The experimentation conceived in support of this objective translates the emphasis from the question, "Can the microform be utilized?" to a question asking, "Will the microform be utilized?"

THE CREATION OF NEGATIVE ATTITUDES

An investigation of the acceptance of microform presentation must center on the individual, his expectations and needs as a receiver of communications. Basic to the discussion and arguments presented in this introduction to the experiments conducted is that the only motivation for student use of microform stems from satisfaction of perceived information needs. It must be clear that the strength of this motivation varies both from individual to individual, and that it varies for an individual over time. We must presume a microform system that has a sufficient information reservoir to meet routine information demands and recognize that acceptance cannot be considered seriously until it is explored in a context of the routine use of microform presentations when satisfying these demands.

It was recognized early in this program that user dissatisfaction with microforms was always expressed in terms of discrepancies; e.g., image won't stay in focus; dirt on the fiche; scratches on the film strip; screen too bright; can't get comfortable; and so on. An attempt was made to organize these complaints within a conceptual scheme so that a statement like "The reader's no good," could be probed further for specific failures. This attempt at organization was unrewarding until the process of recognizing discrepancies was itself probed. An individual recognizes that something is wrong only when he knows something about the possible relevant alternatives. In the case of microform presentation, the relevant alternative is a book or hardcopy.

> The key to organization of discrepancies articulated about microform use is to recognize that the student user perceives microform as a hardcopy substitute.

The reason that this idea is difficult to accept (and certainly it has not guided educational practice, nor is it obvious in commercial applications) is that the nature of the relevant alternative has not been formalized in the user's mind. The process of formalizing the characteristics of the relevant alternative (the book in this case) is the same process that creates negative attitudes concerning the microform presentation. The negative attitude develops from unsuccessful comparison of specific characteristics of the microform with the same specific characteristics of hardcopy. This comparison cannot be made until the user is forced to formalize his ideas of just what hardcopy characteristics are: the discrepancies surrounding a microform presentation force the formalizing activity. We believe that these ideas are critical to understanding the acceptance problems surrounding microform use. Because of their importance, a restatement is attempted.

An individual grows up using hardcopy. This form is accepted and utilized without the user having to understand what characteristics are embodied in the hardcopy that facilitates its use. Consider, now, what occurs when the user reads a microform presentation--and the lower portion of the image is slightly out of focus. He may refocus that portion of the image many times, dismissing the problem as only "part of the system." But, somewhere along the line he will begin to think: "You don't have to do this all the time with a book." This is the stage of formalizing the alternative; where its characteristics begin to be identified and a comparison model begins to emerge. Each time refocusing is required after formalizing has been started, negative attitudes are reinforced. With the occurrance of other discrepancies in the microform presentation, the corresponding characteristics of hardcopy are formalized and the comparison model becomes more mature. It should be emphasized here, that a major discrepancy for one person may be trivial to another person.

In summary, it should be clear that the existance of an alternative forces any process to be evaluated as a means to an end rather than being evaluated in terms of the end benefits alone. (There being no real substitute, the telephone system is not evaluated in terms of an alternative, only in terms of the value and ease of communication that can be achieved with that system.) The presence of an alternative will continue to affect microform acceptance until the microform offers greater value than just "substitution." In the long run, the substitute role will be minimized as technology breaks the hardcopy link by using other inputs than the printed page itself: in the short run, microform must depend on creative publishing concepts to enhance the information value, and on a direct attack on system discrepancies of the medium itself.

ACCEPTANCE FACTORS

Recognition of hardcopy as the basis of the user's comparison model has prompted the organization of discrepancies into three classes: equivalence, accommodation, and adaptation.

1. Equivalence concerns those aspects of presentation that the microform and the hardcopy have in common.
2. Accommodation concerns those aspects of physical difference between the microimage-reader combination and the hardcopy which affect the ease of task accomplishment.
3. Adaptation concerns those aspects of microform use which have a system dependency. These factors range from environmental considerations to technical barriers in implimentation of the system itself.

A heirarchy of factors is formed through this classification method. Each higher classification includes the preceding in building a framework for acceptance. In this way, factors operative at the equivalence level also internalize the adaptation level. Table F-1 presents this classification scheme along with some examples of discrepancies. No attempt has been made to be inclusive, nor are the listed discrepancies limited to a particular microform. It should be clear to the reader that these factors do not have the same weight, nor do they affect acceptance independently. The experimentation described below attempted to identify the most important factors as well as to probe for relationships.

Table F-1. The Classification Scheme for Acceptance Factors

1. EQUIVALENCE: Concerning Presentation Discrepancies

   - Uniform brightness of screen
   - Uniform focus over image
   - Proper margin balance
   - Uniform image contrast
   - Lack of dirt or scratches
   - Readability of image
   - Lack of scintillation (screen characteristics)
   - Image polarity
   - Illustration quality
   - Screen color and image tone

2. ACCOMMODATION: Concerning Task Accomplishment

   - Manipulation of fiche or film strip (positioning)
   - Note taking process (abstracting)
   - Frame-to-frame interference (distraction)
   - Isolation of single frame from complete work (continuity)
   - Frame-to-frame focus
   - Skim, scan, and search modes, versus reading
   - Eye legible information requirements

3. ADAPTATION: Concerning Environment and System Design

   - Reader size (flexibility; portability)
   - Ambient illumination and reader noise; ambient noise
   - Positive and negative blowback (variable magnification)
   - Screen size and screen angle
   - Bibliographic control
   - Access to microform reservoir
   - Uniform quality in microforms
   - Reader-printer demands
   - Maintenance

EXPERIMENTATION

The experimentation conducted in this phase of the investigation asked fundamental questions in terms of the acceptance concept. The constraint operative in the design of each experiment was the fact that only a single experiment could be conducted (except for the contrast experiment) and as much information was sought as was possible. While each experiment focused on a specific acceptance classification, other factors were included if it was convenient. It was felt that this experimentation would serve to provide an overall context for the question of user acceptance by identifying critical factors so that more refined experimentation can eventually be undertaken. Three experiments were performed, and they are identified below, together with major acceptance classification to which they relate.

Table F-2. Acceptance Experimentation

Experiment	Focus
Contrast (in three parts)	Presentation discrepancies
Search (single study)	Accommodation or task discrepancies
Preference (single study)	Adaptation to reading

CONTRAST EXPERIMENTS

These experiments, three in all, were organized to determine if the performance of a student could be related to differences in presentation. Two reader presentations were chosen which, in the opinion of the investigators, were very different from each other in terms of their respective discrepancies relative to hardcopy. This work focused on the mechanism or stimulus required in order to force the individual to begin creation of his comparison model and to determine if his performance was independent of his attitudes towards particular discrepancies. The two types of presentations used are shown in Figure F-1. The reading material consisted of monographs*

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*The materials presented on fiche were 16 articles which previously had been behaviorally differentiated into two discrete groups, distinguished as "easy" and "difficult" and characterized by high reading rate-high comprehension and low reading rate-low comprehension, respectively (Appendix B).

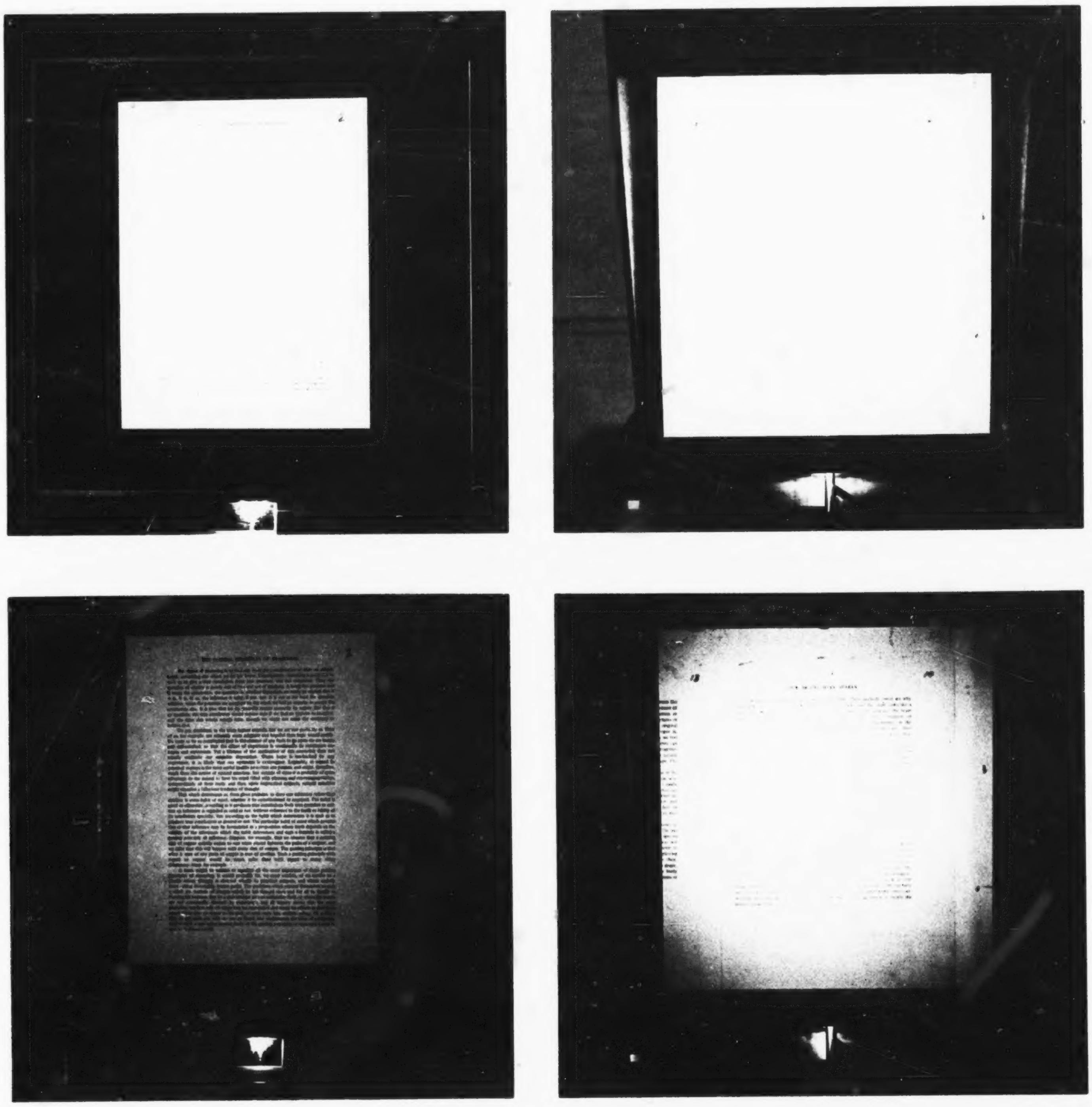

Figure F-1. Reader Presentations Used for Contrast Studies, Compared at Two Exposure Levels to Indicate Difference in Brightness and Uniformity: 46x Reader, Left; 38x Reader, Right.

having high, and approximately equal, image readability. The principal distinctions between the respective presentations are tabulated in Table F-3, and the physical arrangement is shown in Figure F-2.

In each study, eight students were used as subjects; for Study A, subjects were Freshmen and Sophomores from the College of Arts and Sciences; in the later studies, B and C, undergraduate students from the various Colleges were used.

The Experimental Design

For each of the three studies, a repeated measure design with random block order of presentation was employed, through which each subject was exposed to every combination of treatment level: two readers and two classifications of article difficulty. Each student encountered four easy and four difficult articles on each of the two readers, for a total of 16 articles presentations. The entire design was counter-balanced for initial exposure to readers and levels of article difficulty (half the students encountered the 46x reader first and half encountered the 38x reader first; half of the students from each of these two subgroups saw an article categorized as easy first, and half saw an article categorized as difficult first).

Study A. The two classes of articles were combined orthogonally (two easy and two difficult articles for each trial) and presented to eight students in a counter-balanced series of four trials.

Study B. The two classes of articles were combined orthogonally (one easy and one difficult article for each trial) and presented to eight students in a counter-balanced series of eight trails. This study was an exact replication of Study A except that the number of trials was increased from four to eight and, therefore, the number of exposures to each of the two readers increased from each reader's being encountered twice in Study A to each reader's being encountered four times in Study B.

Study C. The eight articles at each level of difficulty were presented as a group; i.e., the students saw all eight articles for a given level of difficulty, and then saw all eight articles of the other level of difficulty. Two articles were presented at each trial, in a counter-balanced series of eight trials to eight students.

Table F-3. Reader Presentation Characteristics

46x Reader	38x Reader
Screen	
colorless	green color
Delph - no scintillation effect	glass - scintillation effect
no bright spots	bright spot in center
90° angle from table	tilted slightly backwards
noise from machine fan	silent
Fiche	
46x reduction	38x reduction
glass covered	bare film chip
no dirt or lint on image	dirt (lint) on image
material on two rows	material on one row
black border; no overlap of other images	no border; images on other frames show with projection
Newton rings	no Newton rings
Focus	
uniform over entire screen	not uniform over entire screen
sensitive "fine tuner"	not sensitive "tuner"
Brightness	
approximately 7.6 foot-lamberts at center of screen	approximately 35 foot-lamberts at center of screen
Readability	
grain pattern reading of 7.2	grain pattern reading of 6.7

The general environment for testing was maintained constant; room illumination was diffuse (approximately 60 foot-candles).

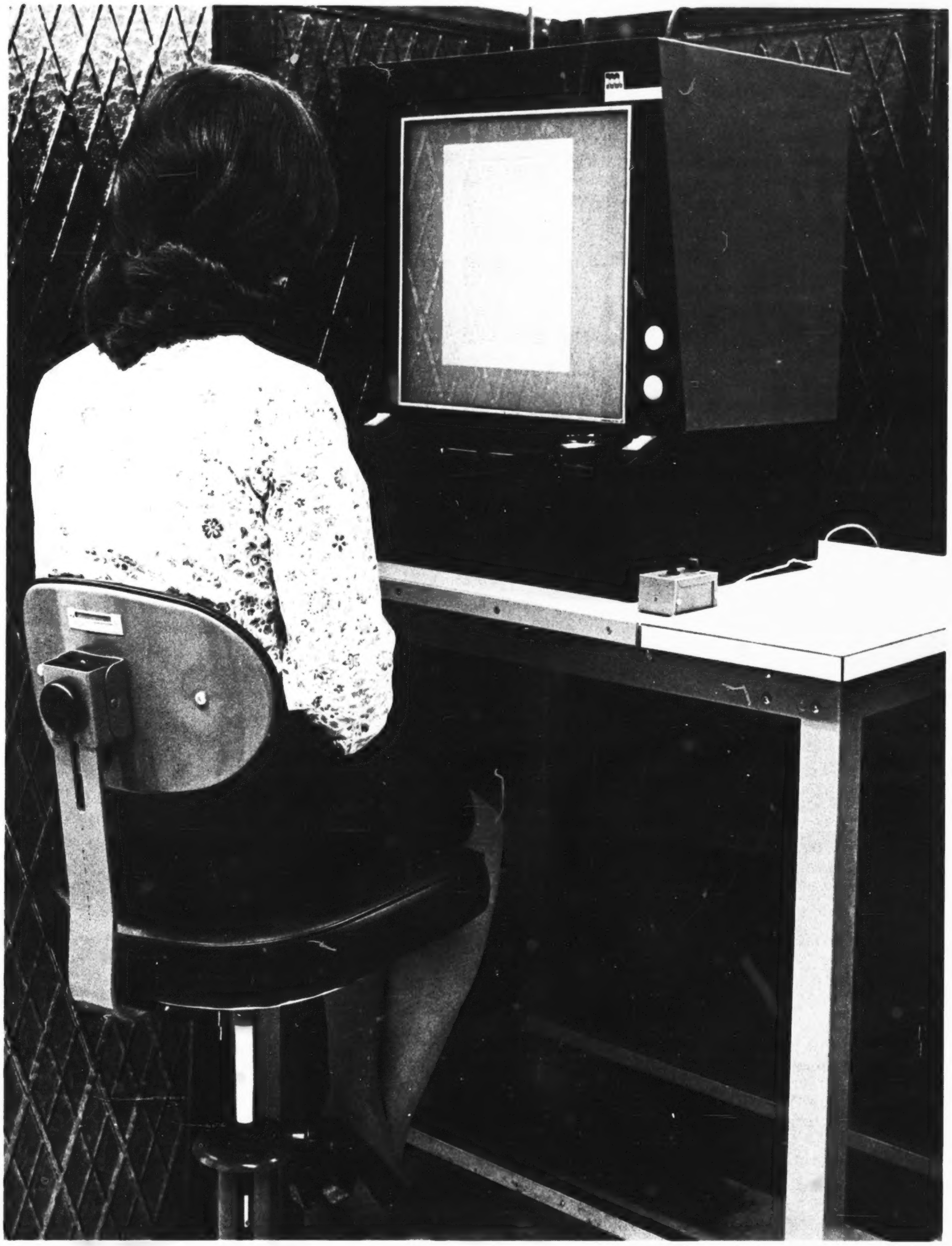

Figure F-2. Physical Arrangement for Contrast Studies.

Studies B and C were conducted to answer certain questions that arose when the results of Study A were analyzed. These latter studies were also expanded to illicit subject response to specific questions of discrepancy (subjective). All studies were stabilized by comprehension questions administered immediately after each reading.

Experimental Results

The test hypothesis of Study A was that no difference in performance could be associated with presentation differences (the 46x reader or the 38x reader). The analysis of variance for the complete experiment showed no significant difference between subject response to the different reader presentations, although the average reading rate was higher for the 46x reader. If, however, subject response was analyzed for differences when reading the "easy" portion of the material (eight of the sixteen articles presented) a cyclic performance pattern was observed in which reading rate was consistently high for the 46x reader and lower for the 38x reader. The experiment provides a complementary result to that obtained in the initial performance investigation (Appendix B) in which different, but not statistically significant, reading rates were associated with specific readers for only the easy material. If the experiment were recast to ask, "Is there a performance difference, associated with contrasting presentations, that is also dependent on the demands made on the student by the material difficulty itself?", then the answer is affirmative. Figure F-3 presents the initial conceptualization of these results. The principal features of this graphic presentation are: (1) reading rate decreasing with increasing difficulty (shown as a linear decrease X-X', for lack of abscissa scale, (2) a cone of variance that decreases as the readings become more difficult, and (3) the association of reader presentation differences with variability for the "easy" material.

A number of behavioral variables have been ignored in this representation, but at this point it is useful to summarize the effect of the inherent difficulty level of the reading by introducing Studies B and C. These other considerations (such as motivation) will be discussed in a context of results from all three studies.

Study B was conceived to test whether it was possible to "open" the cone of variance by simply increasing the number of exposures or cycles that the subjects encountered. It was reasoned that the differences in presentation would become more important as the subject

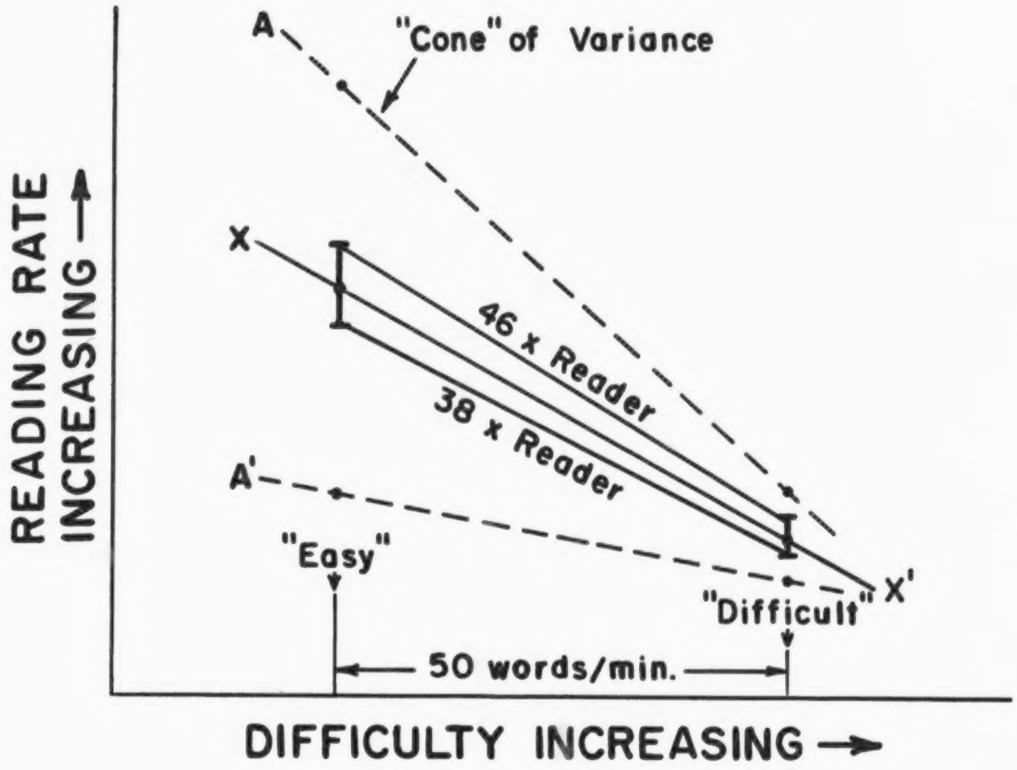

Figure F-3. Conceptual Interpretation of Performance (Study A).

saw them contrasted more often. This reasoning was based on the idea that the subject must formalize his own model of necessary presentation characteristics and that this process would be facilitated if more opportunities to see differences in presentation were afforded. This is precisely what occurred. The analysis of variance showed a significant machine effect (alpha = 0. 05) across both levels of material difficulty and that the variance attributed to machine effect was about the same for the "easy" material as compared to the "difficult" material. The results at this stage suggested that the sensitivity to presentation differences is controlled by the demands that the material itself make upon the subject in the absence of highly contrasting presentations repetitively seen. In other words, as the reading material becomes easier, the subject is in a better position to consider other aspects of the total experience and, for a single presentation setup (no contrast), difficulty of task controls a "gating" or "awareness" function. Study C was conceived to explore this question

If it is successfully argued that the presentation differences are "matured" in the mind of the subject by increasing the opportunity for contrasting these differences, then it can be argued that the effect of reading difficulty must also be sensitive to contrast. In the first two studies, the student encountered a balanced arrangement of the material levels. In Study A, two difficult and two easy articles were presented before the subject moved to the other reader; in Study B, one difficult and one easy article were presented before reader change. In the final study (C), the student was presented only one level of material, either difficult or easy, but the level was maintained until all eight monographs in the class were finished before he encountered the remaining level. After two readings were completed, he changed readers in order to continue (same cycle as Study B). The expectation in this study was that the students would evidence the performance variation of Study B but not independently of difficulty level. This, however, was not the case. The significant machine effect was gone. The performance did reflect the difference in difficulty between material levels, but it is clear that performance effects associated with differences in presentation are stimulated by changing demands in the material itself. The most surprising aspect of this study was to find that the cyclic pattern in performance associated with changing the readers was completely missing, yet the difference in reading rate across material levels was preserved (about 50 words per minute difference). The explanation for this behavior is that all the material was perceived as difficult, with the net effect that the abscissa values were shifted to the right in the Figure F-4. The conclusion is that the subjects were less able to consider other aspects of the experience that lay outside the reading task itself. The variance introduced by machine differences was only one-tenth that of Study B. As further evidence of a perception effect, the comprehension performance was significantly improved for the 38x reader, the only time that comprehension analysis in any study showed a reader dependency. The comprehension for the 46x reader was typical of other studies.

Table F-4 summarizes all three studies. Since a different group of students was involved in each study, the average reading rates are expected to be different. The fact that the reading rates in Study C are lower than the other studies may be due to chance alone. It should be noted that performance was always better on the 46x reader, even though it is significantly better (statistically) for only Study B. When the performance is collapsed over machine differences, the performance dependency on the difficulty of the material is seen as 50 to 55 words per minute; a consistent difference for each study.

The complete interpretation of these three studies is beyond the scope of this report, and separate publication is anticipated. The glimpse at basic behavioral characteristics that these studies have afforded demands that a complete context be developed in which the roles of motivation, comprehension questions, and the order of material presentation, be formally considered. The concepts of adaptive behavior and cue theory have an important contribution to make in the analysis of these studies as well. Finally, the combinations of performance measurement in a non-learning context, together with a strong stimulus field outside the task itself, must also be considered in a complete conceptualization. This complexity dictates the summary statements which follow.

OPERATIONAL ACCEPTANCE

Two points can be made relative to the overall question of acceptance based on these studies of presentation differences. First, performance can be modified by differences in presentation; differences which fall outside the question of readability. It is clear that the individual is not immediately aware of discrepancies in presentation; the opportunity for contrast calls attention to the presence of discrepancies, and initiates the individual's development of his unique model

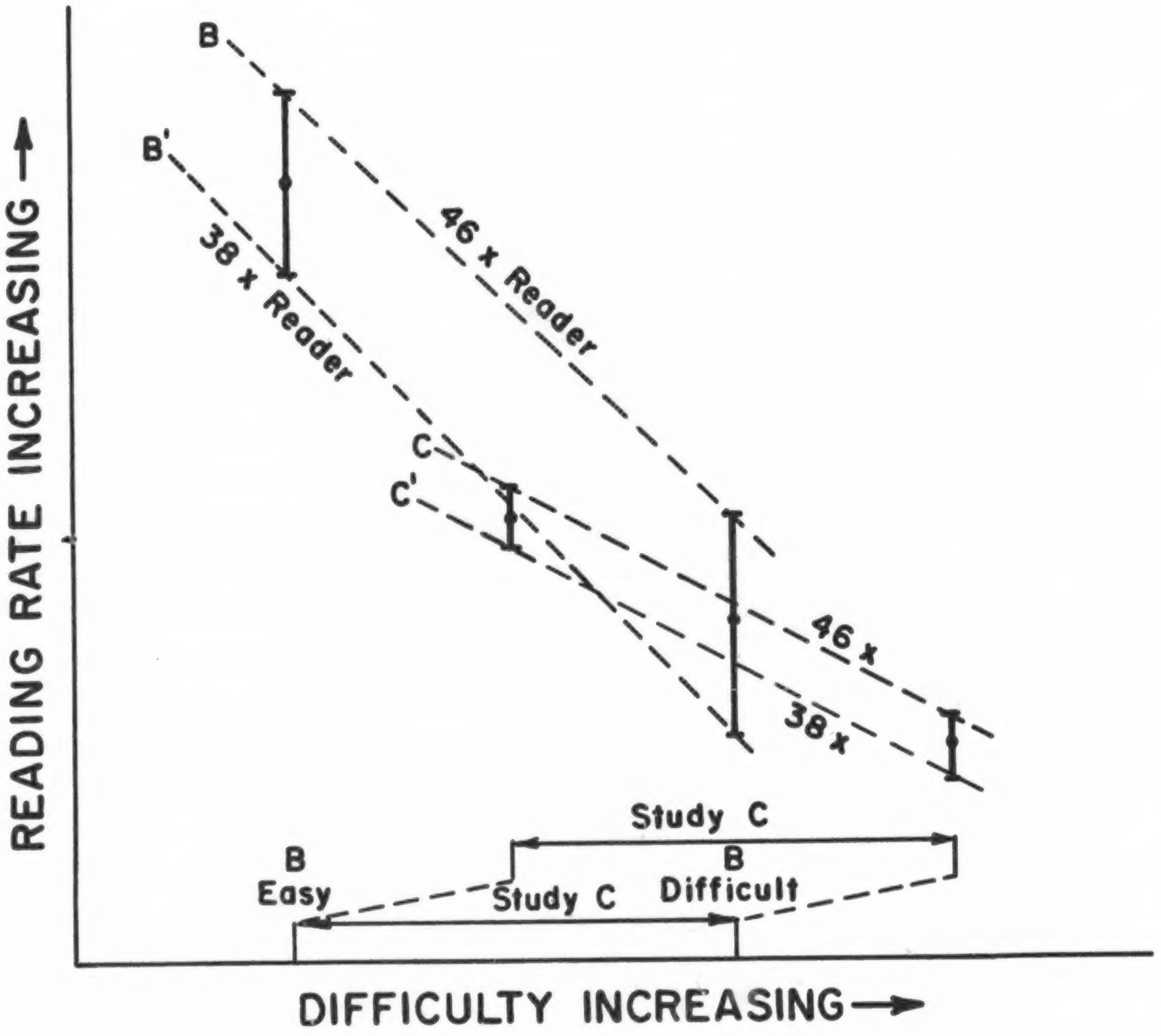

Figure F-4. Performance Versus Percieved Difficulty.

Table F-4. Average Reading Rates for Contrast Experiments

Presentation	Study A	Study B*	Study C
		(Easy Material)	
46x Reader	349	347	309
38x Reader	330	308	295
(Average)	(339)	(328)	(302)
		(Difficult Material)	
46x Reader	289	302	257
38x Reader	280	254	242
(Average)	(284)	(278)	(250)

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*Significant difference between performance on readers (machine effect: Alpha = 0.05) for suitable presentation. Secondly, the perceived difficulty of the reading task controls the subject's awareness of stimuli lying outside the reading task. This is a higher order response than that of the presentation differences; the presentation differences, as they affect performance, are minimized when task difficulty is high but not contrasted to establish "how high."

The development of a unique model by the subject can be given further dimensions. The subjects in both the B and C studies were asked to evaluate the important aspects of the reader presentation by ranking eight factors that were suggested by the investigator. These eight factors are divided into classes consistent with the acceptance factors in Table F-1, and the results of this procedure are presented in Table F-5. The significant feature of this table is that focus and screen characteristics are seen by all students as critical, but the other factors are perceived uniquely. For instance, the importance of a dust-free fiche was ranked from 2 to 8. This procedure has introduced the concept of discrepancies existing in two forms: either reinforcing or non-reinforcing. A discrepancy may exist in one form or the other depending on the particular use made of the reader. Discrepancies in maneuverability are reinforcing when a search task is performed, but could be non-reinforcing if sequential reading is the task. A reinforcing discrepancy calls attention to itself as each frame of information is presented; a non-reinforcing discrepancy, such as fan noise, image color, or room illumination, may cause an initial reaction but the importance diminishes over time.

It should be clear that focus and screen discrepancies are of the reinforcing type and any reinforcing discrepancy should be minimized in any microform application.

"SEARCH" EXPERIMENTATION

An experiment was designed in which accommodation aspects of microform use were the main consideration. The student's ability to "search" a complete title (some 560 pages) was probed, as well as his ability to work between hardcopy and the screen image itself. The primary material for this study was a basic volume on "Personal Finance." The book was chosen because it was highly readable and had an enormous range of data presentations in the form of charts, graphs, and illustrations. Basically, the subjects were asked to give a written response to some 63 questions that were developed from the text.

Table F-5. Ranking of Selected Presentation Factors

	Importance Index	
EQUIVALENCE:		
Focus	1.4	reinforcing
Screen (brightness, uniformity, etc.)	2.1	
Dirt on film chip	4.7	conditionally reinforcing
ACCOMMODATION:		
Fiche positioning (maneuverability)	4.7	
ADAPTATION:		
Noise (fan)	5.4	non-reinforcing
Chair positioning	5.5	
Position of reader	5.6	
Ambient illumination	6.0	

These questions required the subject to locate the relevant material within the body of the presentation and then to abstract the appropriate information from the presentation. Usually a single word response was sufficient to answer a question. A student often had to read relevant information in the text and then relate this to a chart or graph in order to develop the correct response.

In addition to these task oriented activities, the experimental setup was modified so that the student could adjust the reader position, the internal and the ambient brightness, and the screen angle (adaptation or environmental aspects). The apparatus and reader are illustrated in Figure F-5. These adjustments were made at the beginning of the tasks, reviewed again after about half an hour, and again at the end of the search task. Following the search task a period of short-story reading was performed to contrast the two types of activities, i.e., search and reading. Since it was planned that these same subjects would be asked to participate in further studies, the readings were important as an example of what would be expected if a subject returned later for further experimentation.

Experimental Procedure

When a student arrived to participate in the experiment, an overview of the DRI project was given for the student's benefit to orient him as to his role in the program as a whole. Time was allowed here for questions on the part of the student. Then, he was asked to be seated in front of the reader to be used, and the height of the machine was adjusted to suit him; the desk or writing area in front of the machine was adjusted to his preference. The machine was also tilted to the angle (backward or forward) which the student found most agreeable. After that, the researcher demonstrated the mechanical operation of the reader and the fiche, and permitted the student to manipulate the equipment for a few moments and to ask questions that might facilitate his performance. The brightness of the screen was raised and lowered until the student found a screen brightness which he felt was good, and the room illumination was likewise changed through the range from zero to 64 foot-candles to the ambient lighting level which the student thought to be best.

When these various adjustments had been completed, the student was given 20 questions which pertained to the text on the subject of finance; this was in the nature of a "warm-up" in use and manipulation

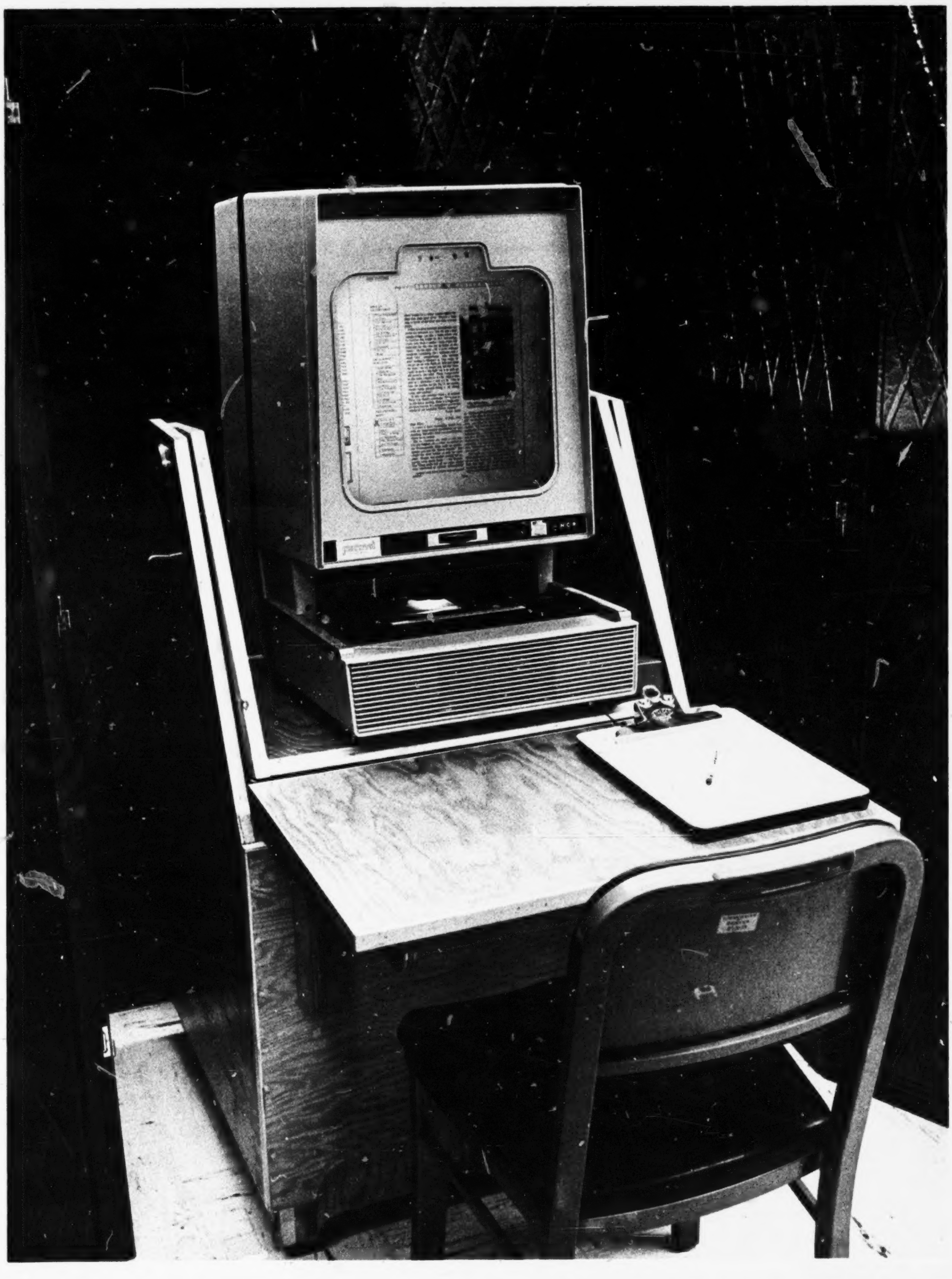

Figure F-5. Positioning Apparatus and 115x Reader Used in "Search" Experiments.

of the equipment. When the student finished this warm-up, he and the researcher again talked about the study; any adjustments that the student now wished to make in the screen angle or brightness, or in the room illumination, were done at this time. Following this indoctrination session and warm-up, the student was given 43 more tasks to perform in retrieving and recording information from the finance book. When this body of search tasks was completed, the student was permitted to relax and discuss any observations that might have occurred to him during the course of his performance. His activities up to this point had all been timed so that the difficulties encountered in a particular category of search task could be studied later. Comments were solicited but no structured questions were asked. The timing of the tasks was accomplished by monitoring a pressure-sensitive switch installed in the clipboard which held the question and answer forms. The time interval between successive responses was monitored on a remote chart recorder.

The experiment closed with each student's reading at least one short story. Four subjects were released before a second reading was undertaken because the testing time had become excessive (longer than three hours). The various environmental parameters were again reviewed with the student and adjustments made if desired before the readings were begun. Again, comments were solicited at the conclusion of the readings.

The Nature of the Search Tasks

In search and retrieval, depending upon how the material is organized, a person will proceed in a predictable fashion to obtain data. For instance, when the material is organized by numbering figures sequentially and a particular figure number is called for, one might go directly to the proper figure, in frame sequence, and obtain the data. In other instances, it might be necessary first to go to a list of figures at the beginning of the text and search through figure titles to find the right reference, and then to go to a particular page. For a subject reference, it might be necessary to go to a subject index, or to a chapter heading to find the appropriate information sought.

The particular book which was used in this test was selected because it contained many different kinds of figures and tables, with many different kinds of type, as well as complete introductory and index guides for the location of the material covered. The various tasks were divided into categories as follows:

a. Abstraction, which was the abstracting of data from three sources: (1) the textual portion of the book, (2) a figure or table, (3) conclusions, suggested readings, or discussion questions.

b. Location, which included two sub-categories: (1) where the use of appropriate index leads directly to the page on which the answer is found, (2) where the use of appropriate index leads to the general area of the correct answer.

c. Indexing, which included questions that could be found by using one of the various indices for figures, tables, contents, general subject index; and the converse, no-indexing, which involved no use of indices.

All of the questions to be answered were evaluated separately in all three of the above categories. For instance, all questions could be dichotimized by indexing or by type of abstraction.

By timing the response to questions graded in this fashion, the various types of search tasks could be studied to see what particular problems there might be and what solutions might be necessary to make information search on fiche satisfactory and efficient from the user's (student's) point of view.

General Results

The review of the data developed thru this experimentation and of the comments derived from the students provides excellent commentary on the nature of the student population, completely outside the context of the microform use. As a matter of fact, a test of this type would be useful for personnel managers who need to identify personal characteristics for matching certain types of job requirements and job applicants. This thought is not trivial because the search task was, indeed, a difficult and probably over-long experiment. As it progressed, it was clear to the investigator that any additional motivation (beyond the monetary) which might be traced to an interest in the program objectives had vanished early. In terms of performance only, it was useful to divide the students into four groups:

1. those who performed rapidly and accurately (3 in number)

2. those who performed slowly with poor results (3 in number) and a transition group comprised of:

3. those who performed rapidly with poor accuracy (2 in number)

4. those who performed slowly but accurately (4 in number).

One observation that could be significant is that 5 girls were in Groups 1 and 2 while 5 boys were in Groups 3 and 4, but this difference will not be pursued. Table F-6 presents a summary of the characteristics exhibited by these groups; Table F-7 presents the details of performance in terms of the three categories of search task and the group averages for the last 43 search questions, Table F-8 summarizes the accuracy of the groups, again in terms of the categories; Group 2 had particular difficulty with text abstractions--seen again when only general location information is available. Overall, the speed improved between the warm-up and the actual study, but the accuracy went down slightly; an expected result considering the balance between learning and fatigue.

Student Comments

Because of the highly personal experience reflected in this experiment, the subject's comments and characteristics are presented individually for greater insight. (F = female; M = male).

GROUP 1

(F). Student F. The search was made up of "boring material" in her opinion. She felt the process on the reader was comparable to a book but she wanted to have the machine a bit closer to her. She seemed to ease out of an initial "bad mood" as more interaction took place between the researcher and herself. For short stories she wanted the lights turned off in the room. She did not use indices unless it was necessary and after a short time she knew where everything was in the material.

(F). Student G. Said "The flashing by of the pages makes me a bit dizzy." Otherwise, she commented on how well the whole process

Table F-6. Evaluation of Group Characteristics

Group 1 Students:

- Appeared to be highly motivated for the task
- Tended to improve from warm-up to actual study
- Requested more contrast across reader interface through adjustment of room illumination and screen illumination as study progressed
- Did not miss (individually) many questions on the search
- Finished the entire study more quickly than other students (including the readings)
- Were highly interested and appeared more highly motivated for the task
- Gave more creative and specific suggestions as to how the use of ultrafiche might be improved than other students
- Scored high on comprehension questions for short stories which required retention of story details

Group 2 Students:

- Appeared to be less interested and less motivated for the task than others
- Did not improve from warm-up to actual study (the only group that did not)
- Requested less contrast across the reader interface as the study progressed
- Had the greatest tendency to give up on attempting to read very small print
- Shared with Group 3 the distinction of most search questions missed per person, particularly on the actual search portion
- Gave only vague and noncreative suggestions as to how ultrafiche might be improved
- Scored the lowest of any group on comprehension questions for short stories
- Took more time to do both the search study and the short story study than any other group
- Had extremely rapid reading rates on final articles of short stories (almost as if this group were "giving up" and skimming thru the last tasks).

Group 3 Students:

- Moved through the search material more rapidly than any other group

Table F-6 (Continued)

Missed more search questions than any other group per person, but many were on warm-up indicating improvement

Improved in every case from the search warm-up to the actual study in time taken per task

Tended to ask for less contrast across the reader interface as study progressed

Group 4 Students:

Second slowest in performing search tasks

Second highest in number of search questions per person answered correctly

Second in time taken to finish the search study

Tended to prefer greater contrast over reader interface as study progressed

Appeared to be motivated for the task

Improved (from the search warm-up to actual study) in time taken per task (except for one individual)

Table F-7. Students' Performance on Search Tasks in Time Taken (in seconds)

				(Specific)	(General)	(Abstracting from:)		
Group	Student	Indexing	No-Indexing	Location 1	Location 2	Text	Figures	Conclusions
(1)	F-1	117	34	83	156	179	91	115
	G-1	102	25	71	120	99	72	96
	H-1	99	21	73	96	88	70	72
(Average)		101	33	86	103	99	85	79
(2)	A-2	117	33	83	156	179	91	115
	J-2	175	55	129	167	163	132	136
	E-2	156	33	99	176	163	99	133
(Average)		149	41	104	166	168	107	128
(3)	K-3	96	27	73	98	93	75	78
	D-3	93	30	71	96	89	74	78
(Average)		94	29	72	97	91	75	78
(4)	B-4	98	25	77	108	108	82	199
	L-4	108	21	89	109	87	98	93
	M-4	149	32	87	146	107	91	105
	C-4	140	28	108	152	104	108	183
(Average)		124	26	90	129	101	95	145
OVERALL AVERAGES:		117	32	90	126	116	92	111

Note: Each entry in the table represents the average time for all tasks of a specific type within each category.

Table F-8. Questions Missed on Search Tasks (by Category and Group)

				(Specific)	(General)		(Abstracting from:)		
Group	No. of Students	Indexing	No-Indexing	Location 1	Location 2	Text	Figures	Conclusions	Totals*
(1)	3	9	0	5	4	1	5	3	9
(2)	3	20	4	9	15	11	8	5	24
(3)	2	10	1	8	3	1	8	2	11
(4)	4	10	2	8	4	2	5	5	12
OVERALL:		49	7	30	26	15	26	15	56

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* The questions are all evaluated three different ways and each is tabulated 3 times; total is actual number of questions missed by group, regardless of category.

works once "you get used to it." She found reading much easier than search for her, although she felt the search actually would be easier than reading for other people. She preferred the room lights turned off and the screen as bright as possible. "I want it as much like a book as possible." A cheerful type of individual. Finished the study in 2 hours and 40 minutes. Occasionally she used short cuts to get answers.

(F). Student H. Stated that she would like it better if the entire screen were filled with print; also would like the print to be larger. She would like to get closer to the material. After the warm-up wanted the lights turned out and the screen tilted back further away from her. On the warm-up she found it too easy to overshoot the desired page. She said she would like a book much better for search tasks. She felt the process would be easier with a book. She got a bit tired and didn't like the "greenness" of the screen. On short stories she liked the fiche better than a book because she could help herself to read faster by moving vertically down the page and could move from one page to the next faster. On reading she still wanted larger print to fill the screen.

GROUP 2

(M). Student A. A sullen, quiet type of individual throughout the study. It took him 4 hours to finish. On search tasks he stuck to the general format of using indices to locate material. He didn't like the fiche losing its focus (said this happened gradually until he couldn't see the material any longer). He became annoyed at question 27; said it was hard work doing the search. He didn't find reading the short stories nearly as fatiguing as the search problems.

(F). Student J. Speaking of the search, she said "It's tricky, but once you get on to it, it works pretty neat." She liked the fiche as well as a book for the search tasks. She was a bit nervous when beginning and a little slow in catching on at first. She found the search with fiche better than using a book and said "It's an easy process once you catch on." She did not mention focus problem. She lost her nervousness during the search. She doesn't like looking up information in general but became more relaxed and cheerful as study progressed. She used indexing for almost all of the questions on the search. She enjoyed the stories more than the search and said she didn't enjoy the search because there were so many tasks in the study.

(F). Student E. She liked the reader better than a book for search tasks. She couldn't explain why. She used indexing most of the time for search tasks and wanted nothing changed once the lighting and reader had been set at the beginning of the study. Before she read them, she felt she would not like reading short stories from the machine and afterwards said she didn't like reading short stories from the reader because she wanted to "curl up with a book." She became quite uncomfortable in the reading position. She is a large girl. She did feel the print was very clear.

GROUP 3

(M) Student K. For the search tasks, he said he would much rather have a book. The pages flashing by bothered him. The mechanical operation of the equipment he found fatiguing. Overshooting desired pages presented a problem. Usually he used indexing to find answers. He found it a little difficult to move the fiche around and thought a book easier to page through. On reading short stories, he liked the fact he didn't have to hold up a book. He found the process satisfactory, but was not very sure of himself.

(M) Student D. He used indexing most of the time but occasionally used a chapter for searching. He was rather tired after the search and asked for cigarettes, pop, a break. He liked the permanency of the reader - he didn't.have to hold the material. He said his eyes got tired with the lights off, so the lights were turned on low. He liked reading stories much more than the search, but would like a more comfortable chair, one in which he could lean back and change positions from time to time. He said the lighting was better than with a book because you can illuminate the screen however you like. He thought not having to hold the material made one less tired than with a book. He felt the small print (equivalent to 3 to 4 point) was not legible enough for the most part. He got tired of leaning forward to see the fiche and would like to bring the screen closer at times.

GROUP 4

(M) Student B. He appeared as if he "wanted to get this thing over with." Seemed he was present to make a few dollars at first. Later on he appeared more conscientious. He said he enjoyed the process and he never became annoyed or irritable. He liked the short stories better than the search. He took 3 hours and 15 minutes. He stuck fairly well to the format of using the indices.

(M) Student L. He complained about focus after the initial warm-up. He stated that his eyes got sore during the search tasks and would like a book much better for search. He didn't like the fact of overshooting the mark when trying to find specific pages. For reading stories, he wanted the screen facing directly at him (no tilt) and wanted internal illumination turned down for the stories. He liked reading stories much better than doing the search tasks; he felt the flashing by of pages on the search made the eyes sore. He finally ended the study with the screen tilted towards him.

(F) Student M. This individual worried about the study before beginning: "Do I have to be smart?" After the warm-up she stated she liked the process and said "It's fun." She felt it was different and new (a novelty). After the search portion of the study she stated that she felt the reader to be more "clumsy" than a book but it was interesting material for her. She wanted the reader closer. She appeared to be quite fatigued when finished. She stated she'd like the reader next to her on the left, but closer. She worried about not being able to underline pages on the fiche that she thought to be important. She was tired and took 5-10 minute break. After finishing the short stories, she said she liked the fiche as well as a book, and liked not having to hold anything, but said also she sometimes wished she could handle the reader so she could assume various positions; still wanted the reader in closer. She didn't like the formatting and said it bothered her and was distracting. She looked and said she was very tired. Most of the time during the search she used indexing.

(M) Student C. While doing the search, he did not like having to re-focus all the time and would like a book better for search tasks. He usually made use of indexing but if near a particular figure on the fiche would not use the index. Mostly used the Table of Contents. He liked reading stories much better than doing search tasks. He enjoyed the fact that he didn't have to hold up the reading material and felt there was less glare from fiche than there would be on hardcopy. He wished that the focus would stay fixed and clear for a longer time.

Conclusions

The principal conclusion that can be drawn from the performance phase of this study is that a range of specific tasks, germane to a student's use of microform, can be efficiently performed on a high magnification,* high-density, reader-fiche combination. The principal facilitating recommendation that this experiment suggests is that the information should be organized on the fiche vertically, by column, rather than horizontally, by row. While there are other reasons for this recommendation, the specific criticism relating to search that would be largely negated by this new format is that of the student's feeling of dizziness. This proposal is feasible for high-density fiche materials because there are enough frames in a column to allow the information to be organized effectively; the only point made here is that the need to re-frame every image is no longer necessary with the vertical format; only columns would need to be framed. The student's reaction to "overshooting" the desired page would be effectively removed since the image can be advanced vertically without discomfort as the eye contact is not broken if the advance is slow and, if rapid, the complete information line is presented whenever motion ceases--a very important feature when searching for specific information; the subject can immediately begin scanning for relevance without an additional frame adjustment.

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* 115x

The environmental adaptations were quite informative. First, it may be concluded that a subject will orient the reader so that his eyes are in the center of the screen vertically. Further, that the reader screen angle should be parallel to the subject's face when he is in a writing position. This angle is about 5 degrees from the vertical. In order to break tension and reduce fatigue, there was strong requirement for a reader support that would allow it to be moved both toward and away from the subject. This need develops in response to the subject's requirement for position change. When the subject leans backward even a little, the distance between screen and eyes changes enormously. This now appears as an important adaptation demand for prolonged use.

No pattern of brightness preference emerged other than can be ascribed to the subject groupings. Those individuals that "attacked" the job wanted, in general, high screen brightness (30 foot-lamberts on center line). Those subjects that "lived through" the experiment, wanted much lower screen brightness (as low as 15 foot-lamberts). It would appear that variable illumination would be an important feature in any student reader design, particularly because the use can be so variable.

The conclusions that can be drawn from the subjective portion of the study are concerned with the range of behavior that can be expected from the student population. The subjects each formalize subtle presentation differences in a unique way but higher order, more glaring discrepancies are uniformly formalized. The importance of this experiment lies in the demonstration that a demanding task quickly forces almost all of the subjects to make the reader-book comparison or, more accurately, to compare the differences between the two methods of information gathering in terms of completion of the total task. The search tasks were sufficiently complex in the mix of psycho-motor demands and cognitive effort as to make the formalizing process (in which hardcopy characteristics are recognized) a short process. Reading was considered by all subjects to be a much easier process than search, and this difference prompted the first positive comments about microform presentations, i.e., you don't have to hold a book when you read from a screen, and so your hands are free.

PREFERENCE EXPERIMENTATION

The students that participated in the search experimentation were not overly impressed with the opportunity to participate in further experiments. The experimentor usually had to make it clear that search tasks, of the type seen in their initial experience here reported, would not be involved if they returned for further work on the program. It was clear that the students were interested in earning the money (approximately $2.00 per hour) but only if readings were involved. This reaction was not unexpected because each of the staff members found the search task tedious. The advantage in asking these students to return lay in the fact that any predisposition for experimental success could be dismissed. This situation was recognized as advantageous for a certain type of test: that of the individual's selecting the reader of his preference for continued reading.

The Experiment

The basic idea behind the preference experiment was to have each student read a short story on each of four different readers; after the readings were completed, the student was asked to select a reader in order to complete two more short story readings. The objective of this study was to determine if preferences had identifiable patterns and, if so, what the basis of preference might be. Four specific situations were created in the test set up: (1) the 38x reader was always used with a negative image creating 12% positive blowback such that the information and formatted material* just filled in reader screen; (2) the 120x reader was fitted with a mask on the final projection mirror so that the image just fell within the aperture; the fiche was made with a 1/2-inch black border around each frame which allowed about 1/2-inch of positioning error before light showed between the outer edge of the frame and the mask aperture; (3) the 46x material had a striking brown tone associated with the print and illustrative information; the information area was small compared to the screen size, and the surrounding area was opaque; this gave the same end result as was obtained with the 120x reader except that positioning was not at all critical; (4) the 32x reader presented two frames of positive images; this was normally operated to give one full frame in the center and 1/2 of the adjacent frames on the sides. The readability index of these presentations ranged from 7.6 for the 32x reader to 5.1 for the 120x reader.

It was felt that this range of presentation difference might elicit a common response when the students had an opportunity to make a preference choice; however, this was not the case (as will be discussed later). One difficulty in the design of the experiment was that not all of the material (the short stories) was available in each of the reduction and polarity variations demanded by the readers and presentation designs. These limitations, and the titles of the short stories, are summarized in Table F-9. But, this situation afforded the opportunity to have the students make a second selection of a reader because, no matter what selection was made initially, the remaining story was not available in the appropriate fiche configuration.

This, of course, was explained after the first selection was made and the story read. Three stories were selected from the fiction section of a literature book, and these were matched with three stories of equal length from the nonfiction section. Questions were used in support of each reading in order to stabilize the reading performance. The number of questions varied from 10 to 18 depending on the length of the matched pairs of stories. As an additional source of information about task accommodation, the odd numbered questions concerned story detail that bridged the plot between frames, whereas the even

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*Formatting was used on the fiction section of the book. This included a brief listing of short story titles, major organization blocks, and article length. With formatting, the page was a full 8.5 × 11.0 inches.

Table F-9. Short Stories and Available Readers

	Story	Type*	Setup**	Presentations
1.	The Monkey's Paw	F	NF	120x pos; 46x pos
2.	Diary of a Young Girl	NF	F	32x pos; 38x neg
3.	The Bride Comes to Yellow Sky	F	NF	120x pos; 46x pos
4.	On the Road	NF	F	32x pos; 38x neg
5.	A Mother in Manville	F	NF	120x pos; 46x pos
6.	University Days	NF	F	32x pos; 38x neg

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* F = Fiction; NF = Non-Fiction

**F = Formatted; NF = Non-Formatted

numbered questions concerned story detail from the body of the printed page. The objective in creating these questions was to explore the distraction associated with frame advance, i.e., does the student lose the story line, or is he otherwise distracted, with advancing from one frame to the next? If so, the question response was expected to demonstrate a pattern of lower correct responses for the odd-numbered questions.

The experiment closed with the student's performing a 10-question search task on the 115x reader in which the value of formatting was probed. Figure F-6 is a sample formatted page. The fiction section had no other information than the page itself, while the non-fiction section was completely described in the information table printed just to the left of each frame. A series of five questions was asked about the material in the non-fiction section, and five questions were asked about material in the fiction section. It was felt that the value of formatting, if any, might be apparent in comparing the respective times for acquiring the written responses, or the comparisons might stimulate subjective responses. After completing this phase, the subject was taken through an open-end critique of the various readers and, with this, the experimental data was completed.

Experimental Results

Eleven students were subjects in this experiment,* so the parallel between the search experiment and this preference experiment was not quite perfect. However, this did not affect the major results obtained. The overall performance results are summarized in Table F-10 below:

Table F-10. Comparison of Performance on Fiction and Nonfiction

	Formatted-Nonfiction	Nonformatted-Fiction
Reading rate (average)	256 wpm	257 wpm
Standard Deviation	64 wpm	70 wpm
Comprehension	66%	62%

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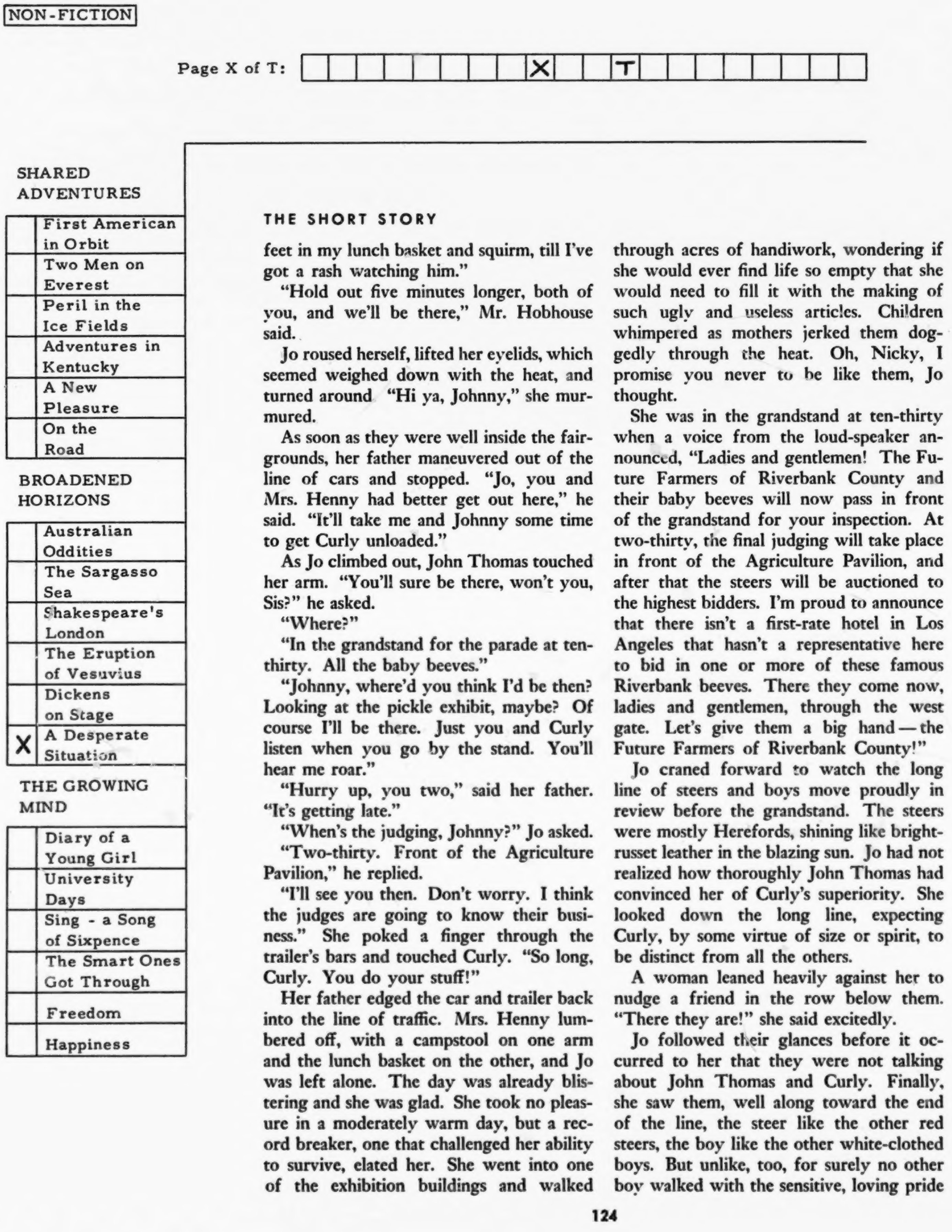
*The twelfth student dropped out of school.



NON-FICTION

Page X of T: ☐☐☐☐☐☐☐☐ X ☐☐ T ☐☐☐☐☐☐☐☐

SHARED ADVENTURES

- ☐ First American in Orbit
- ☐ Two Men on Everest
- ☐ Peril in the Ice Fields
- ☐ Adventures in Kentucky
- ☐ A New Pleasure
- ☐ On the Road

BROADENED HORIZONS

- ☐ Australian Oddities
- ☐ The Sargasso Sea
- ☐ Shakespeare's London
- ☐ The Eruption of Vesuvius
- ☐ Dickens on Stage
- ☒ A Desperate Situation

THE GROWING MIND

- ☐ Diary of a Young Girl
- ☐ University Days
- ☐ Sing - a Song of Sixpence
- ☐ The Smart Ones Got Through
- ☐ Freedom
- ☐ Happiness

THE SHORT STORY

feet in my lunch basket and squirm, till I've got a rash watching him."

"Hold out five minutes longer, both of you, and we'll be there," Mr. Hobhouse said.

Jo roused herself, lifted her eyelids, which seemed weighed down with the heat, and turned around "Hi ya, Johnny," she murmured.

As soon as they were well inside the fairgrounds, her father maneuvered out of the line of cars and stopped. "Jo, you and Mrs. Henny had better get out here," he said. "It'll take me and Johnny some time to get Curly unloaded."

As Jo climbed out, John Thomas touched her arm. "You'll sure be there, won't you, Sis?" he asked.

"Where?"

"In the grandstand for the parade at ten-thirty. All the baby beeves."

"Johnny, where'd you think I'd be then? Looking at the pickle exhibit, maybe? Of course I'll be there. Just you and Curly listen when you go by the stand. You'll hear me roar."

"Hurry up, you two," said her father. "It's getting late."

"When's the judging, Johnny?" Jo asked.

"Two-thirty. Front of the Agriculture Pavilion," he replied.

"I'll see you then. Don't worry. I think the judges are going to know their business." She poked a finger through the trailer's bars and touched Curly. "So long, Curly. You do your stuff!"

Her father edged the car and trailer back into the line of traffic. Mrs. Henny lumbered off, with a campstool on one arm and the lunch basket on the other, and Jo was left alone. The day was already blistering and she was glad. She took no pleasure in a moderately warm day, but a record breaker, one that challenged her ability to survive, elated her. She went into one of the exhibition buildings and walked through acres of handiwork, wondering if she would ever find life so empty that she would need to fill it with the making of such ugly and useless articles. Children whimpered as mothers jerked them doggedly through the heat. Oh, Nicky, I promise you never to be like them, Jo thought.

She was in the grandstand at ten-thirty when a voice from the loud-speaker announced, "Ladies and gentlemen! The Future Farmers of Riverbank County and their baby beeves will now pass in front of the grandstand for your inspection. At two-thirty, the final judging will take place in front of the Agriculture Pavilion, and after that the steers will be auctioned to the highest bidders. I'm proud to announce that there isn't a first-rate hotel in Los Angeles that hasn't a representative here to bid in one or more of these famous Riverbank beeves. There they come now, ladies and gentlemen, through the west gate. Let's give them a big hand — the Future Farmers of Riverbank County!"

Jo craned forward to watch the long line of steers and boys move proudly in review before the grandstand. The steers were mostly Herefords, shining like bright-russet leather in the blazing sun. Jo had not realized how thoroughly John Thomas had convinced her of Curly's superiority. She looked down the long line, expecting Curly, by some virtue of size or spirit, to be distinct from all the others.

A woman leaned heavily against her to nudge a friend in the row below them. "There they are!" she said excitedly.

Jo followed their glances before it occurred to her that they were not talking about John Thomas and Curly. Finally, she saw them, well along toward the end of the line, the steer like the other red steers, the boy like the other white-clothed boys. But unlike, too, for surely no other boy walked with the sensitive, loving pride

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Figure F-6. Example of "Formatting" for Orientation within Text and Chapter (Story).

Since there was no apparent difference between the performance on fiction or non-fiction when performance was collapsed across students, a ranking scheme was developed in which the group performance could be compared as a function of the reader and specific short story. The scheme weighed the individual performance, together with the relative difficulty of a story, to obtain a performance index. The point of this comparison was to understand what happened when the student made his selection of reader in terms of performance difference. These data are presented in Table F-11. The table also shows which reader was selected for the fifth reading. The important results here are:

1. There is no reader that was generally preferred of those selected. The reader presentation demanding careful frame positioning (120x) was completely excluded for just that reason. Although the inconvenience was minimal, in this instance the fact that the subject had to contend with framing demands made him reject the reader unequivocally. The reasons for the specific choices made always hinged on the fact that a certain type of system discrepancy was minimized in the subject's mind; e. g., this reader maintains focus from frame to frame; that reader is easy to frame images; this has good fiche maneuverability. The surprise was that each of the readers selected were given these same attributes.

2. Once the selection was made, the overall performance index sharply increased. Whatever the reason behind a choice, it is clear that once the choice was made it was reflected in improved performance.

Seven students did not choose the 46x reader initially; however, six of the seven made this reader their second choice. This presentation, in the opinion of the project staff, had the fewest discrepancies overall of any available for the study; those of importance were fan noise and front surface reflections.

The comprehension questions which were designed to explore the distinction of frame advance, as well as to stabilize performance, gave no indication that thought continuity is broken with the framing of a new image. Only 7% more questions were missed on the "bridging" material as compared with the questions from the body of pages. While this comments on a specific set of conditions, there is no reason to believe that a problem exists in this area. The few search tasks accompanying this study were performed with just the opposite result

Table F-11. Performance Ranking for Preference Experimentation

	First Four Readings Students' Performance on:				Fifth Reading (Presentation Preference)	
Student	120x	32x	46x	38x	Performance	Selection
1	-2	-1	-1	1	2	38x
2	1	-1	1	-1	-2	32x
3	-1	-1	1	1	-1	46x
4	-1	-1	-2	-2	1	46x
5	-1	-1	1	1	2	38x
6	1	2	-1	-2	1	46x
7	1	1	-1	1	2	32x
8	-2	-1	-1	2	1	46x
9	-1	-1	1	-2	2	38x
10	-2	1	2	-1	2	32x
11	-2	-2	-2	2	2	32x
Summation Index	-9	-6	-2	1	12	4 at 32x 4 at 46x 3 at 38x

Note: The above performance numbers have the following meaning:

1 = easy material read above student's mean reading rate on all 6 articles

2 = difficult material read above student's mean reading rate on all 6 articles

-1 = difficult material read below student's mean reading rate on all articles

-2 = easy material read below student's mean reading rate on all articles as was expected; formatted material took longer to search than the non-formatted. The subjects explained that the table of contents was more appropriate to the search task and the time difference was associated with the fact that the formatted material was further away from the table of contents on the fiche than was the non-formatted. The general attitude was to forget about the formatting entirely; it was distracting.

Table F-12 presents the subjects' reactions to the question of image polarity. At the end of the experiment, positive and negative fiche were demonstrated in each low magnification reader; the polarity preference is tabulated, together with comments. The key to the preference for the negative-38x reader combination lies in reduction of hot spot effect by the negative image. The 38x reader was less bright than the 32x reader: 35 foot-lamberts versus 55 foot-lamberts along the centerline of the screen. This suggests that brightness alone is not the reason, rather that the negative image is preferred when a brightness gradient is present over the screen area.

The responses of the subjects to post-experimental questioning indicated that they were attending to what they thought was important at the expense of other variables. Several students indicated that they didn't notice the quality of the pictures on the negative image (which were sometimes difficult to distinguish) and, almost unbelieveably, two students failed to notice that the 38x reader screen was green in color. Although almost all students noticed dirt, etc. on the 32x fiche (both positive and negative) when it was specifically pointed out to them, few reported noticing it while attending to the accomplishment of the task and none said that it bothered them in any way.

Conclusions

Three different reader presentations were given preference by the subject group, each selection being based on the same reasoning; each was selected for maintenance of good focus, and for easy, smooth fiche positioning compared to the other two readers. Obviously, some other combination of factors must have influenced the individual decisions, with focus and positioning being the only discrepancies that the student could articulate. This behavior is strong evidence for the concept that each student is forced to develop his own individual model of what constitutes a good presentation, and that this process is highly differentiated within a group of subjects. This experiment serves to identify two of the most important discrepancies and demonstrate that

Table F-12. Negative vs. Positive Image Preferences

	32x Reader		38x Reader	
Student	Negative	Positive	Negative	Positive
1	x	Too bright	x	
2	Too dark and gloomy	x	x	Too bright
3		Saw dirt but wasn't bothered x	x	Too bright Too dirty
4	x	Not enough contrast of print on background	x	Didn't like green with background
5	Kind of dark	x	x	Made screen jump at you
6	x (but not definite)	A little bright	x	Screen bothered
7	Kind of made print jump out at you	x	x	Screen bothered
8	No preference, both were dirty		No preference, disliked green screen with both	
9	x	White on black was easy to read	x Much better	No glare - didn't notice green screen
10	Couldn't decide		x	Too fuzzy on green screen
11		x Nice, bright, and clear	x	Too dirty

Totals: 4 = Negative 5 = Positive 10 = Negative 0 = Positive
2 = Undecided 1 = Undecided

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x = preferred

the relationship between and among other presentation variables is very subtle. In actual fact, both the focus characteristics and the maneuverability of the three readers are quite similar; the choices must be seen as an overall preference comment.

FURTHER COMMENTS ON ACCEPTANCE

The experiments described and interpretation given the results obtained represent only the first steps that can be taken in exploring an enormously complex problem. However, this is the appropriate time to attempt to summarize what we have learned in the course of 14 months' work.' We feel that acceptance of microform presentations is first of all controlled by the value of the information to the user. If this hurdle can be overcome, then the acceptance model, as roughly developed here, comes into play. We feel that the concept of discrepancies forcing the user to formalize the attributes of the alternative i.e., "how does using a book compare with this presentation factor?" is an important advance because it aids the systems designer in his response to differing microform applications; only the nature of the alternative changes with differing application.

Finally, it can be concluded that serious, meaningful uses of the microform presentation minimizes the user's awareness of the details of presentation, while frustrating or trivial uses maximize the user's awareness of discrepancies in the presentation.

APPENDIX G*

THE APPLICATIONS OF ULTRAFICHE TO COLLEGES AND UNIVERSITIES

by

James P. Kottenstette

and

Alta Bradley Morrison

The applications of microforms in colleges and universities as a consequence of technological advances in microimagery (which permits great density of information on very small film areas) are considered in the context of user (student) information requirements in two areas: (1) "structured" information needs which are associated with the predictable, planned, organized, formalized materials associated with the college classroom activities, and (2) "unstructured" information needs which are the result of the diverse, unique, individually-oriented, separate pursuits of students searching for information on their own initiative. The paper suggests that microforms can help to meet the unstructured information needs of students through the creation of large collections of titles on film and by creating a communications network for computer search of library works, and further suggests that microforms can play a new and exciting role in meeting structured information needs related to the classroom so that a greater body of material can be associated with this area of student educational experience. It is stated that communication of the subtle and abstract must be achieved across the man-machine interface associated with the film-reader combination and that quality is paramount in achieving this information transfer. The belief is expressed that problems now hindering rapid proliferation of microforms in education are artificial and that with acceptable presentations these problems will be quickly solved.

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*As presented at the 35th National Meeting of the Operations Research Society, held in Denver, Colorado, June 17-20, 1969, this paper presents the conclusions reached during the conduct of the 1968-69 University of Denver ultrafiche study as to possible educational applications of this communications medium.

INTRODUCTION

A research program, sponsored by the United States Office of Education,* and having the same title as this paper, has created an opportunity for comment on the larger role of microform in information science, in addition to providing basic insights into the application of ultrafiche to colleges and universities. This fortunate circumstance can be traced to the belated recognition of ultrafiche technology as simply an extension of the inclusiveness of microform applications, distinguished primarily by the number of document pages that can be stored on a single film card. The high frame density obtainable through this technology can be appreciated by considering the products that are commercially available: under the trade name "Mindex," Microform Data Systems, Inc, prepares film cards with 400 pages (8.5-by 11-inch originals) stored per square inch of fiche. The National Cash Register Company, under the trade name PCMI, prepares 3,200 images on a 4- by 6-inch fiche. This density compares with the 60, 70, or 90 images stored on the various "standard" microfiche in common use.

It has not been attractive (up to now) to consider publishing book materials in fiche form (although it is being done on roll film) because multiple fiche would be required; ultrafiche offers the possibility of not only a complete book, but multiple books on a fiche and, hence, the current interest in its possible application to colleges and universities. Once it was established that the high reduction ratio used to obtain high frame density was not a factor that limited the application to selected or especially prepared documentation, it became clear that the range of application was much broader than originally suspected, and that the microform could affect fundamental processes in information science, especially in education.

This paper will discuss some of the applications of microform to colleges and universities. These applications include both ultrafiche and conventional forms: a distinction that is artificial once it has been recognized that the choice of a specific microform is legislated by the relationship between the particular nature of the information itself and the most effective microform for utilizing the information. As each application is presented, an attempt will be made to project a narrow example into the arena where fundamental processes or information management and utilization can be understood.

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*Bureau of Research, Division of Information Technology and Dissemination.

The value of this type of presentation is always diminished by the realities of the present, therefore, we ask, "How does one transform an existent system into one of greater value?" Each application described includes a modest attempt to identify a starting point where transition could and is being initiated, and this effort is complimented in the last section of the paper where the viability of the microform medium is discussed.

THE PERSPECTIVE

A description of the microform applications being considered would be premature at this point. It seems important to ask, "What are the present applications of microform in colleges and universities?" This question might best be answered by considering that existing microform applications reflect an administrative solution to one problem in the acquisition of library resources. Microforms as presently encountered in the institutional setting, serve a limited user base. Specifically, the materials available in microform are of interest to a limited audience, and the microforms acquired by the library are generally for purposes consistent with limited usage: i. e., materials relating to research, archives, back-issue maintenance, storage, etc. The implication here can be stated: the applications for microform in education have totally new dimensions when a large and inclusive user group is assumed. The concept of a large, inclusive user group is basic to the applications described and is essential for understanding the larger role of microforms in information science.

The large user group in a college or university is, of course, that institution's total student body. In the simplest sense, this group has two types of information needs: one type is "structured" and to an extent, predictable, while the other is "unstructured" and spontaneous. The "structured" information needs arise in the organized, formal classroom process and are clearly the most pervasive information needs of the user group. One important characteristic of these structured needs is that they are planned and are differentiated conveniently by the curriculum offered by the institution. Further, while the user group is differentiated in the same way, the individuals in the subgroups formed by the various courses of instruction, have common information requirements. The "unstructured" information needs of this user group arise from the individual's perception and interpretation of his own immediate requirements. These needs are characterized by diversity, spontaneity, and uniqueness. While it would be an oversimplification to view the library role as only a response to unstructured needs of the students, it is clear that the essential library function is a response to demands of the unstructured kind. This premise suggests that the information demands on an institution can be divided into types: those which are classroom related and those which are library related, with existing microform applications limited to expanding the library's capability to respond to unstructured demands only in sense of increasing the information base for accommodation of diversity.

APPLICATIONS

The most advanced microform proposals that could affect colleges and universities in the short run are designed to create large ultrafiche collections. The two best known of these proposals are the "UMF Resource and Research Library Series" proposed by Encyclopedia Britannica, Inc., and the recently announced subscription series proposed by the National Cash Register Company. These two proposals are related in that both propose to offer complete titles (one or more) in fiche form, and the initial publication effort will exclude copyrighted material. These two proposals are very different in philosophy, and details of execution, but the point of interest here is that both are based upon the "large collection" concept. The nature of the material selected for these publications is consistent with the unstructured information needs of an institution: i.e., enlargement of the information base. But, the impact on the user base is minimized by the historical character of the material.

In one proposal, 20,000 titles are offered for about 15 thousand dollars; the other proposal offers 3,500 titles yearly at a cost of approximately one dollar a title.* The importance of the publishing effort can be appreciated when it is considered that four hundred colleges now have collections of less than 18,000 titles and that acquiring 20,000 titles would cost close to 250 thousand dollars shelved, in hardcopy form (and this figure ignores physical plant costs). This picture is distorted, however, by the fact that the material for the planned collections is specialized to avoid copyrighted material; a "core" collection of 20,000 volumes would be more expensive because of the added copyright costs associated with royalties; and it is further distorted when the range of existing library collections is examined for duplicate holdings.

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*One dollar a title is author's estimate

The second area of microform application considered here is also tailored to unstructured information needs. This potential development draws on the technology of computer search and expands the capability of the library to meet individual requirements. The system foreseen might operate in the following way: An individual identifies key words and phrases consistent with his problem. A tape, maintained at a regional center, is then interrogated and the "addresses" of relevant abstracts are specified from this central source. These data are received at the requesting library and the "static" files of abstracts (which would physically reside in each participating library) reflecting all of the tape entities, are interrogated by address and the abstracts evaluated for relevancy and for location of the complete work. There are currently at least three microform equipment manufacturers that offer the computer-reader interface, with the complimentary system having enormous file sizes and automatic access to specific frames as called upon. There has been significant work done in the improving of search methodology* for conventional library titles: the Regional Dissemination Center (National Aeronautics and Space Administration) offers an experience base for the search process of a significant class of information (700,000 titles, chiefly reports and documents). The ideas that should be emphasized here are: (1) the abstract files would be available locally for immediate evaluation, and (2) this development is not prompted by savings in cost; rather, it is prompted by benefits in improved response to unstructured information demands (the spontaneity of individual needs).

Since the title base in machine-searchable form for this application does not exist at this time, nor has the editorial work been performed for abstracting book materials, the first step to achieving this end might be for the larger institutions having significant scientific and technical programs to become part of the Regional Dissemination Center network. The abstracts of this RDC documentation are presently available and could be most easily committed to the appropriate microform for the creation of local files; then, as experience is gained, the MARC-II tapes of the Library of Congress could be used as a base for creation of search tapes and for abstract development of typical library materials. Developments along these lines will be forthcoming because the problems of rapid identification of relevant material are common to all institutions. The efficiency of the microform as an information management tool is virtually untapped in the educational field, but the fact that this data base is common to all such institutional users will facilitate its arrival.

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*Gerard Salton. "Progress in Automatic Information Retrieval," Colloquium Lecture, University of Denver, 17 February 1969.

The third area of application pertains to structured needs, and is the most difficult of the three to describe adequately because it is a departure from the present way that structured information needs are treated. As mentioned earlier, structured information needs are a consequence of present instructional methods. In terms of total demands, the structured needs are the most pervasive at any educational institution. This pervasiveness is confirmed by the presence of the "book store" and the acceptance of a textbook as the usual method for supporting classroom instruction. The ultrafiche technology presents an alternative for meeting these structured needs. Before describing this alternative, it would be well to reflect on why the textbook is presently used, and focus on its main limitation. Basically, the textbook offers a convenient vehicle for instruction: it is organized in a logical manner, and each student is brought to a common reference plane. A particular text(s) is selected by the instructor in response to his individual judgment and prejudice, and at the undergraduate level, particularly, the viewpoint projected is normally the only one encountered. This is not a serious drawback because the instructional level is generally basic, and the student cannot be expected to purchase numerous texts in support of each class. The library itself offers direct compensation for this problem in that other sources are made available. The point that should be evident is that the textbook, its content and form, have evolved in response to factors that subordinate the information content to marketing considerations. If the argument is acceptable, it follows that a modification of the marketing constraints might also modify the interpretations of structural information needs that are classroom derived.

One possibility for new interpretation lies in the concept of "information units." A parallel might be drawn between the concept of information units and the relatively recent publishing innovation in which authors write various sections of a book, with the sections unified by an editor or editorial board. The concept of information units is an extension of this approach. The chief difference is that the scope or range of the materials presented would not be restricted to a certain length as decreed by marketing judgments. In the short run, these information units might simply be the selection of books having a common theme, organized by difficulty or competing viewpoint, but unified by presence on a single film card. As this application becomes mature, the information units would become a bridge between report material and text material with each unit drawing on whatever source and to whatever extent is dictated by the editorial objective. The most important aspect of this concept is that the structured information base would no longer be so limited as in the past and would be far more responsive to the pursuit of knowledge in a given course of study. This concept directly affects information science and has social implications as well.

These are two immediate barriers to implementing this concept: (1) copyright law, and (2) the need for individual readers (machines). Both of these barriers are artificial. The reason that readers are not available at a cost and in a form that would meet this need is, of course, a comment on the material that is presently available in microform. Current microrecorded information has limited value to most of the students in colleges. The information unit concept keys on structured material that does have value for large groups of users, and reader technology will respond to meet the needs that are created. The copyright question is much easier to answer. The publishers of copyrighted material will publish in microform if it is profitable to do so. A real barrier lies in the fact that nobody knows yet if information units have a market. The successful creation of large collections in ultrafiche will comment significantly here, because the multiple titles possible on a fiche can be considered as information units in a restricted sense: if a demand develops for individual fiche, this will be an important market indicator. Perhaps the earliest demonstration of a market for microform information units will originate in the "extension service" or "correspondence school" operations of universities or institutes. Since such courses of instruction are highly structured and much of the material is copyrighted by the institution, the decision to create simple information units would hinge on favorable cost considerations and on the effectiveness of the man-machine interface for communications.

The Office of Education has initiated a program* in which specific materials will be prepared in microform to support some 20 courses of instruction at the junior college level, and a major objective of the program will be the evaluation of these materials in the structured context established above. This is a three-year program that could affect the development of core microform libraries as well.

MICROFORM AS A COMMUNICATIONS MEDIUM

The discussion thus far has treated microform applications from the viewpoint of information management, with emphasis on technical possibilities. However, the management of a data base is only important when communication of the information can be accomplished. The suggestion to this point has been that microform is an enormously efficient means of managing information; but, the real debate centers on the question of effective communication. The question of effectiveness focuses on the necessity for a responsive man-machine interface. The essential difficulty here can be seen when this medium is compared with the telephone (since the interface demands are similar), but, with the telephone, the interface demands are not evaluated by the user against a well-known and familiar alternative; he values the use of the telephone in terms only of the benefits to be derived. On the other hand, in the case of microforms, the microimage is used as a substitute for the familiar hardcopy, and the user evaluation is obviously constrained to the demands of the machine interface when the hardcopy alternative exists. This interpretation is reinforced by observing present microform applications: material that is unavailable in hardcopy constitutes the main content of present microform holdings.

If it is assumed for the moment that there are no fundamental barriers at the user-reader interface which would prevent the effective communication of subtle and abstract information, ** then it is clear that microform applications are appropriate to those areas where the form and content of the information base offer benefits in this medium which are not available in hardcopy; further, if no real communication barriers exist, then, hardcopy presentations and microform presentations should be equally acceptable to the user and the choice of medium should be that which is most appropriate for a particular application. This principle of selecting the communications medium offering the greatest benefits in any instance has guided the description of the microform applications presented earlier. Another new development of tremendous significance in this regard is that of optical character recognition. This technology facilitates the conversion of printed information onto a magnetic tape from which any desired presentation format can be made via the computer and the information then directly reduced to microform. Not only is this process less expensive than photographic reduction of original material, but it breaks down a fundamental limitation of current microforms, that of accommodating variations encountered in the printed page, and it permits reformating information as desired. As this technology matures, the present constraints imposed on reader equipment will be modified sharply and the user evaluation will shift from concentration on the machine interface to the benefits that the medium can offer in information availability.

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*The research is being conducted at Oakland Community College, Farmington, Michigan

**. . . as opposed to "data" presentations which are characteristic of most present day commercial applications.

Essentially, the Denver University program has been organized to probe for possible barriers at the user-reader interface. Working with undergraduate students and various types of ultrafiche presentations, the effectiveness of communication across the interface has been explored. These studies have included experiments on reading-rate and comprehension, fatigue, search and retrieval, variations of environmental parameters, and relationships between attitude and performance as affected by presentation quality. No effort will be made here to summarize the results of this work other than to say that a quality presentation is paramount to a completely satisfactory communication. Negative attitudes toward microform use, so frequently encountered, stem primarily from poor quality - in materials, readers, and environment, all of which are conditions that are immediately susceptible to improvement.

SUMMARY

The objective of this presentation was to redefine the range of information needs in education and show the relationship between these needs and microform applications as suggested by technical advances, and to indicate that microforms are entering a period in which microimagery could rapidly mature as a communications medium in its own right rather than merely continuing to provide a hardcopy substitute. Much needs to be done in the area of reader development as well as in behavioral response to the user-machine interface in order to facilitate effective communications with this medium, particularly in the educational environment. This last consideration is recognized because the nature and use of educational materials is quite different from the nature and use of commercial materials where the greatest experience with microforms now resides. The greatest challenge will be the achievement of individual acceptance of the medium for its own merits. The educational application will mature only through quality presentations and a sensitivity to the information needs of students; when and where these needs are met with greater facility, ease, and completeness by microforms, the benefits of the medium will be recognized and it will fulfill its potential.